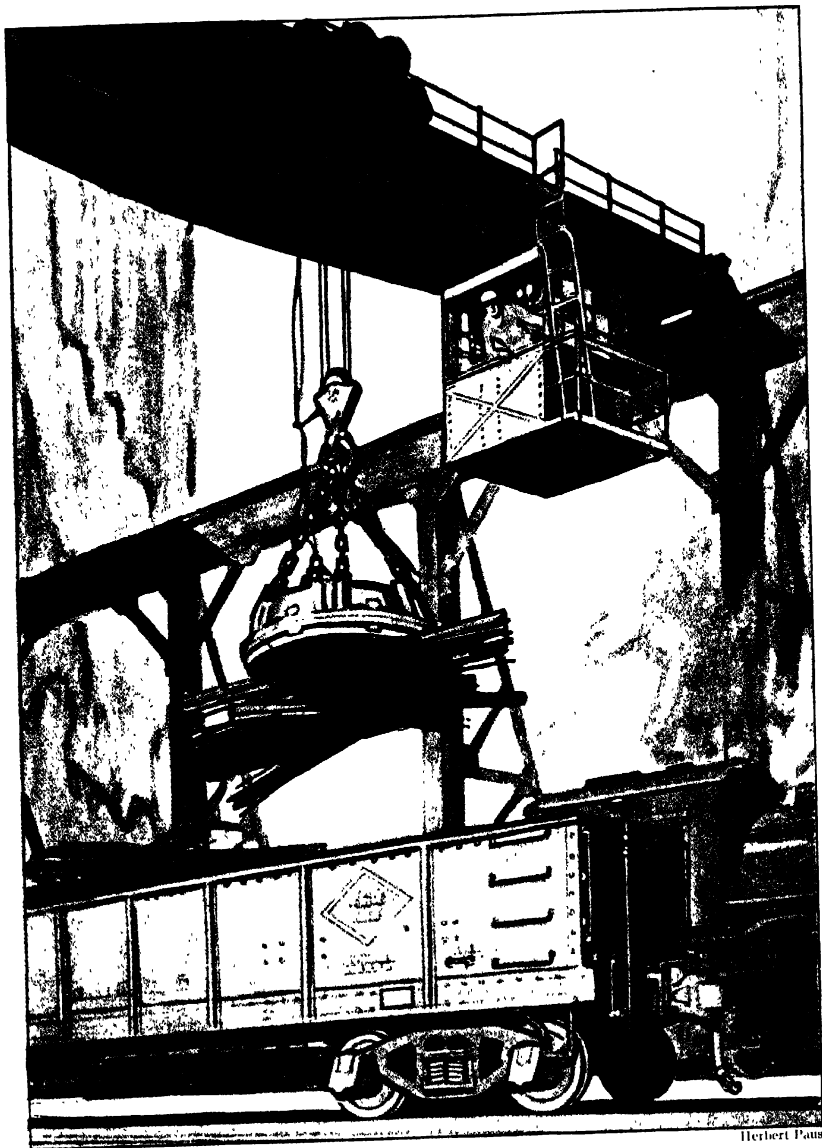


Herbert Paus

One man using machines can lift and move many tons. Without machines he could move only a few pounds. Power aids have helped to build our civilization

Man at Work: His Industries

By

HAROLD RUGG, *Professor of Education*
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and
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PART I

Introducing Our Study





Fig. 1. Miss Harrison's group at work

CHAPTER I

People at Work

THE CHILDREN of Miss Harrison's group in the Emerson School were stumped! That afternoon they were to give a play which they had written, and they simply had to have the teacher's desk up on the stage. They had tugged and pulled and pushed, but move it they could not.

"It must weigh a ton!" grunted Bob, the big boy of the class, under his breath. He had tried to lift while the other children stood ready to push. But in spite of their hard work the desk remained in the same place as before.

Just as they were getting completely discouraged, Miss Harrison, the teacher, came in. After watching their struggles for a few minutes, she said: "Now let's rest for a moment and plan a bit. One thing is clear. Your muscles are not strong enough to lift that heavy desk and carry it to the platform. You do not have enough strength in your backs and arms and legs. All of us could get together and push it, but that would scratch this polished floor. We have a real problem. Let's think carefully. First, is there something that will help us to lift the desk off the floor?"

"My dad uses a block of wood and a crowbar — that's an iron bar with a pointed end — when he

moves big rocks," said Bill Williams. "Do you think the janitor has one?"

"You might ask him," suggested Miss Harrison.

Soon Bill came back with a crowbar and a block of wood. He put the block near the desk, laid the bar over it, and pried the pointed end under the bottom of the desk. Then he pushed down heavily on the bar, and slowly the desk rose a bit.

"There you are!" he said. "We have raised it, but how shall we move it along?"

"I know," exclaimed Tom Bailey. "Put a round stick under it and roll it. That's the way the men are moving Mr. Greene's house on our street. They lay big iron rollers under it."

"Oh, yes, that's the way Mr. Barnes's men moved our piano the other day," put in Sally Gray. "They rested it on a little platform which had wide wheels under it. The wheels were of hard rubber, and the men rolled the piano across our floors without making a single mark."

"I know what to use," said John. "I'll ask the janitor for some old broomsticks."

In a few minutes he returned with three sawed-off broomsticks.

"Just the thing!" said Miss Harrison.

Bob, using the crowbar, lifted one end of the desk while John put one broomstick under it. They lifted again and laid down another stick, rolling the first one toward the middle. The desk tipped down on the two round sticks. The third stick went under the other end.

"How simple!" exclaimed Gladys. She and one other girl easily rolled the heavy desk along the floor while the boys kept putting a stick under the front end as the desk rolled off the back.

"Why is it so easy to move now, Miss Harrison?"

"I know," said Ralph Payne, who was always looking things up in an encyclopedia. "The friction is very much less."

"That's right," said the teacher. "But we'll study more about that a little later. We still have a hard problem here. How can we raise the desk onto the stage? We can't lift it."

"I've got an idea," said Mary Moore, who had been watching the children. "I once saw some men loading a big iron safe into a truck."

"How did they do that?" asked Miss Harrison.

"They put up some long slanting planks and then rolled the safe up on them," explained Mary.

"Let's get some long, strong boards and see if we can roll the desk up onto the stage," suggested Ben.

Ben and several other boys brought some planks and laid them with one end resting on the stage. With several children pushing, and others slipping the rollers underneath, the desk was moved safely up onto the stage.

"Now we can get ready for the play," said Paul, with a sigh which showed how glad he was that the work was done.

What single word tells what Bob and the other children were doing?

It is *work*.

There is, perhaps, no more important word in our language than *work*, because there is, perhaps, nothing more important in people's lives. Let us see how that is true in many communities of our country.

A Day in the Work of Our Community

It is very early in the morning. Everything is quiet, with almost nobody moving on the streets or roads. Now and then an auto or truck passes or a lone walker.

Slowly the sun comes up behind the horizon, far away, and a faint glow begins to appear over the streets and buildings. Here and there a light flashes in a house. A milk wagon rumbles along a street, stopping from door to door, and bottles are heard clinking on the steps.

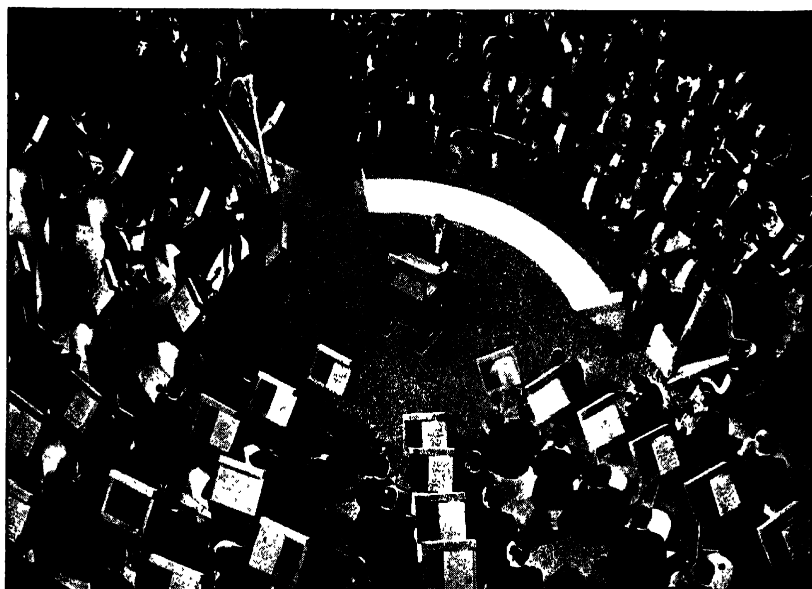
A few more people are moving about in and around their houses, dressing, preparing breakfasts. Bakers' shops and restaurants are being opened; people come out into the streets. More autos pass by.

By seven-thirty, eight, or eight-thirty, there is bustling about everywhere. The community is awake, eating breakfast or going to its work. Each man, each woman, each child, has work to do. There is one man running a streetcar; another driving a truckload of vegetables. Several are arranging things in a market on the corner; another man is working in the drugstore window opposite. Hundreds of people are going into that factory over there. A little later people who work in offices appear, and bankers and other professional men arrive.



Underwood and Underwood

FIG. 2. Members of our national government at work, making plans for the people of our country



Ewing Galloway

FIG. 3. Playing in an orchestra is another kind of work for many people

On side streets are school buildings like yours, and on the hill beyond is the high school. Janitors have the rooms all cleaned; principals and teachers are ready for the day's work. The children come for their work, too; for going to school and studying is their special work.

Musicians can be heard practicing on pianos or other instruments. At the theater on the corner men are adjusting the motion-picture machines. Janitors are cleaning, making ready for the afternoon and evening programs. In the entrance hall of the bank, artists are painting a mural; that is, a picture on the wall. This is to be a mural which tells of the early history of the community.

Workers are arranging books on the shelves of the public library. They are preparing for those who will come to read or to take books back to their homes. At the art gallery paintings and drawings are being hung for a new exhibition. In the health clinic sick people are being examined. At the city hospital doctors and nurses are trying to make people well.

So the morning passes, with each of the thousands of people in the community at his work. Now it is noon — time for lunch and rest. Food is being served in homes and restaurants and hotels. People crowd at drugstore counters or just sit beside their work at a bench or on an auto driver's seat.

The hours of the afternoon begin, from one o'clock to five or six or seven, depending upon the job. Morning work is repeated or continued until a bell or



Ewing Galloway

FIG. 4. Doctors and nurses like these help to make the people of our country well



Lewis W. Hine

FIG. 5. A young sculptress at work modeling a face

whistle or clock tells people that it is time to stop. Then what rushing and bustling follow, with everyone whose day's work is done eager to be at home as soon as possible!

But there are others for whom the day's work is not yet done. Those who run the cars and trains, busses, and taxicabs are carrying people to and fro. That is their work. Cooks and housewives are preparing dinner for hungry parents and children. In order to give pleasure and entertainment to some, others must work into the night.

But evening passes, and bedtime comes. Slowly the community stops working. One by one people go to bed to rest.

The day is done!

What Kinds of Work Are There To Do?

From such a picture of a day in a community we can learn many things about the world's work. Perhaps the most important thing is that there are many, many kinds of work to be done in a country like ours. In these two books of the story of man at work we shall read about them.

Here is a list of some of the chief kinds of work that the people of our country are doing:

1. The work of getting food — plowing, cultivating the soil, harvesting the crop, milling grain, milking cows, and the like.
2. The work of building — digging foundations, putting up steel beams, laying concrete, doing the work of



Lewis W. Hine

FIG. 6. Without the work of the farmer city people would not have food



Ewing Galloway

FIG. 7. A scientist at work in his laboratory

carpenters, plumbers, plasterers, painters, and the like.

3. The work of making clothing — raising cotton and sheep, spinning yarn and weaving cloth, dyeing, making garments, and the like.
4. The work of buying and selling things — in offices, warehouses, and stores.
5. The work of transporting people and things — loading and unloading goods, running horse-drawn vehicles, as well as trains and busses, automobiles and trucks and airplanes.
6. The work of communication — carrying the mail, running the telegraph, telephone, and wireless systems and the railroads, sending personal messages, writing letters, and the like.
7. The work of making people well and keeping them so — examining those who are ill, nursing them, performing operations, and doing all the work of hospitals and health clinics.
8. The work of governing people -- handling traffic, policing the streets and parks, preventing and putting out fires, delivering the mail, running the waterworks, and doing the work of city, county, state, and national offices.
9. The work of educating people — building and maintaining schoolhouses for children and grown-ups, teaching classes, making speeches, holding meetings, and the like.
10. The work of entertaining people — in theaters and moving-picture houses, arranging concerts and pageants, making paintings and sculpture, dancing, making craft things with tools, and the like.
11. The work of the churches — preaching sermons, holding church services, singing in choirs, calling upon the people in their homes, and the like.



Ewing Galloway

Fig. 8. An engineer surveying on the eighty-first floor of the Empire State Building, New York City



Lewis W. Hine

Fig. 9. A skilled workman heating rivets to help in building a steel skyscraper

These, then, are some of the principal kinds of work that people of every community in our country are doing. Can you think of others?

Thinking Jobs, Skill Jobs, and Muscle Jobs

There is another way to think about the many kinds of work that are done by our people. Some kinds of work require mostly thinking, "using one's head." The work of engineers, directors of business, managers of stores and offices and factories, teachers and principals of schools, is of that kind.

Other kinds of work require skill in using one's eyes and arms and fingers. Running a locomotive, an automobile, or other machine, performing an operation in a hospital, are examples of this kind.

There are still other kinds that require muscle strength more than skill and thought. Digging excavations, mixing concrete, carrying lumber, and the like belong to these kinds.

We must not forget, of course, that most kinds of work require all three: the thinking and feeling of people's minds, the skill of their eyes and fingers and arms and legs, and the strength of their muscles. In this book and in the next one we shall study all three kinds of work. As you begin to study each job, be thinking: "Is that a thinking job, a skill job, a strength (or muscle) job, or does it have something of all three in it?"

Books You Would Like To Read

FORBES, W. C. The Romance of Business. Houghton Mifflin Company, Boston. The story of business as we encounter it at the breakfast table. The story of textiles . . . of steel . . . of transportation . . . of electricity . . . of finance and banking.

HINE, L. W. Men at Work. The Macmillan Company, New York. Clear photographs of men and machines.

HUBERMAN, LEO. Man's Worldly Goods. Harper & Brothers, New York. The story of how man earned his living from the twelfth century to the present.

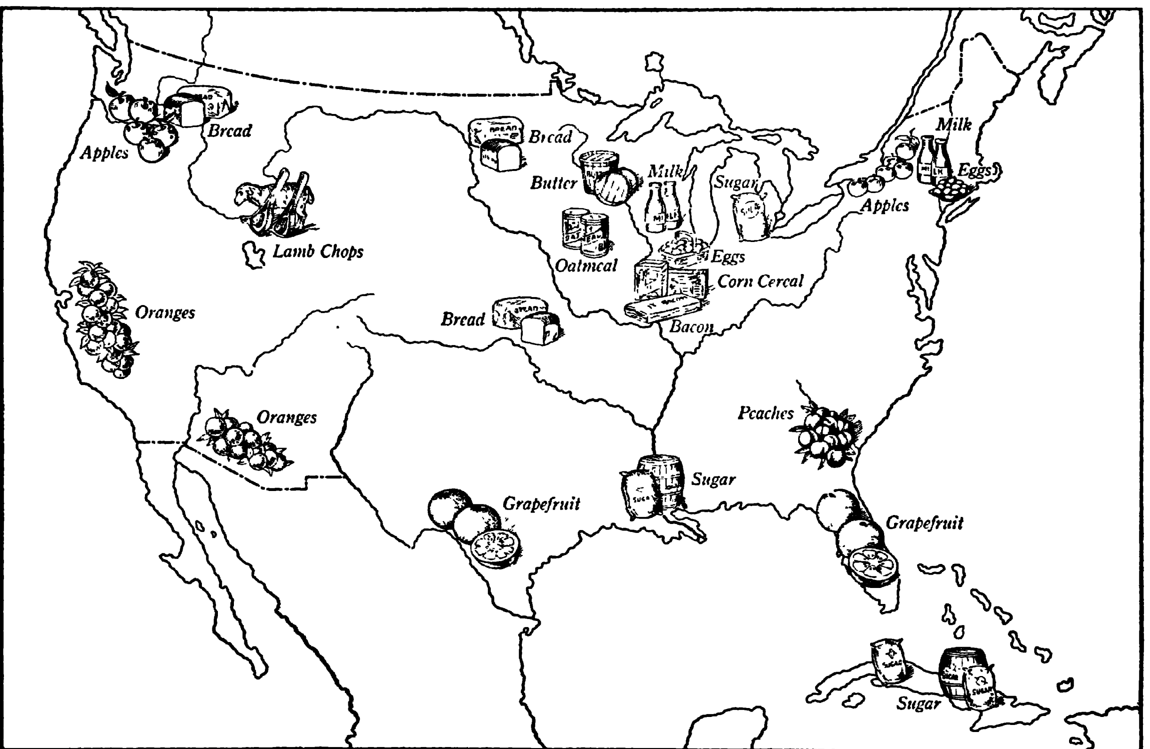
KEIR, MALCOLM. The Epic of Industry. (The Pageant of America, Vol. 56.) Yale University Press, New Haven.

LENT, H. B. Clear Track Ahead! The Macmillan Company, New York. Stories of men at work running trains and doing all the work of the railroads.

LENT, H. B. Diggers and Builders. The Macmillan Company, New York. Stories of many workers -- the cement mixer, the derrick man, the steelworker, the road builder, the truck driver.

ROCHELEAU, W. F. Great American Industries; Manufactures. A. Flanagan Company, Chicago. Motors . . . glass . . . leather . . . boots and shoes . . . dressed meat . . . pins and needles . . . pencils and pens . . . paper . . . printing . . . newspapers . . . books.

TAPPAN, EVA MARCH. Makers of Many Things. Houghton Mifflin Company, Boston. The little friction match; how rags and trees become paper; how books are made; how the wheels of a watch go round; the making of shoes; in a cotton mill; silkworms and their work.



Map 1. How many of these foods did you see on your breakfast table?

PART II

How America Gets Its Food

WHAT did you have for breakfast? Did you have some of the foods shown in the map on the opposite page? Do you know where each one came from? How it got to your breakfast table? Think for a moment of several examples.

First, a slice of toasted bread. Your mother bought a loaf of bread from the neighborhood grocer. Where did he get it? Very likely it was delivered to him by truck from a big bakery in the nearest city. Where did the bakers get it? They made it from flour which a milling company ground from wheat. Where did the miller get the wheat? From a farmer in a near-by county or state. He plowed the ground, planted the wheat seeds, cultivated the crop, and cut and threshed the grain. So the bread really came from the farmer.

The oats that was cooked into oatmeal also came from a farm, perhaps in a state far away. After the farmer raised it, and before your mother served it to you, a big company made it into rolled oats ready to be cooked. Then it was sold to a wholesale store and finally to the retail store from which your mother bought it.

The milk and cream and butter? The eggs? The oranges? After much handling by several companies,

they finally found their way to your family refrigerator.

Remember that all over our country today 127,000,000 Americans are eating breakfasts made up in much the same way.

If you think about the number of things in your breakfast and the other meals, you can see that many people helped to produce the food that you ate. A farmer in one state raised the oranges; another, in a different part of the country, the wheat; others the eggs, the milk, and so on. Truck drivers took them to the city. Workers for various companies prepared them, packed them, transported them, sold them, and resold them. Finally your mother bought them one by one, and she or the cook prepared them for you.

In the next two chapters of this book we shall read stories of how some of this work is done. We shall also see how people prepared their food in earlier times and how they do it in different parts of the world today. These comparisons will make us better able to understand the world in which we live.

Let us begin in Chapter II with the story of a loaf of bread.

CHAPTER II

The Story of a Loaf of Bread: From Wheat Farm to Oven

"HELEN," said Mrs. Taft to her young daughter, "will you telephone Johnson's Grocery and ask them to send a loaf of White's Wrapped Bread with my order? Tell them we should like the kind that has been sliced, and make sure that it came in fresh from the bakery this morning."

"But, Mother, will they have fresh bread as early as this?"

"Oh, yes, Mr. Johnson buys bread from a big baking corporation. He told me that their truck comes over from Kansas City and delivers several hundred loaves to him at seven o'clock every morning. Their new bakery is wonderful; 100,000 loaves are baked there every day, and their trucks go to every town within 50 miles of Kansas City."

Conversations something like that of Mrs. Taft and her daughter can be heard in millions of kitchens any morning in America. Cooks and housewives are ordering food for the families' meals — eggs and milk, butter and sugar, meat and vegetables and pastry. Bread is sure to be included, for it is part of almost every meal — bread for breakfast toast, bread for lunch, bread for

dinner. There is bread in the workman's dinner pail . . . bread with the hamburger or frankfurter at the "hot-dog" stand . . . bread in the sandwiches of the picnic lunch. Today, just as it was said thousands of years ago, bread seems to be "the staff of life."

Should you like to know the history of the loaf of bread which Mrs. Taft ordered from Johnson's Grocery? Then come on an imaginary journey with Mr. Adams of the United States Department of Agriculture. He is an expert on wheat, which means that he knows more than most people about it, and he will be our guide.

From Wheat Seeds to a Loaf of Bread: The Work of the Farmer, the Miller, the Baker

On a warm spring morning early in April, Mr. Adams takes us to Mr. Thomas Mason's wheat farm in Minnesota. We might have gone to a wheat farm in North Dakota or South Dakota, Montana or Canada, for there are many farms where spring wheat — that is, wheat planted in the spring — is grown. Early in the morning we ride out to the level fields on the seat of Mr. Mason's tractor (figure 11).

"It's a good day to begin plowing and seeding," says Mr. Mason. "Good day for any kind of outdoor work. I'll bet that several million farmers are out this morning."

"Remember," explains Mr. Adams, "that although there are many jobs that have to be done, such as transporting the grain and flour by trucks and railroads and



FIG. 10. Traders of several thousand years ago buying bread

boats, there are really three main steps in preparing our people's bread. First, the farmer grows the wheat; second, the miller grinds the grain into flour; third, the baker makes the flour into bread. Here we shall get a glimpse of the farmer's part. You'll see the beginning of it all, for today Mr. Mason plows the soil and gets it ready for seeding. I should like him to tell you about it."

The First Step: The Farmer's Work in Growing Wheat

We bump along over the field as the tractor pulls a plow behind us. We look back.

"You see what a straight, deep furrow the plow turns," says Mr. Mason. "All I have to do is to drive this tractor back and forth across the field. The engine does the pulling, and the plow turns up the soil."

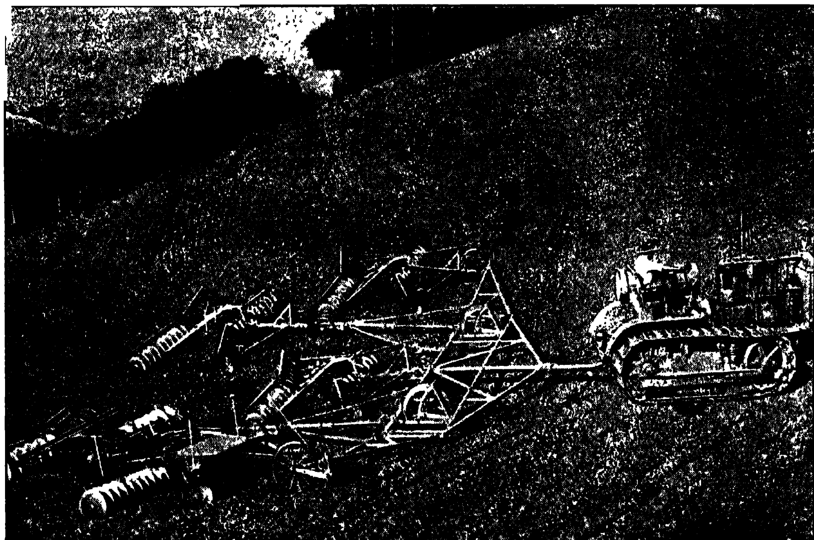
Back and forth we go, at a steady rate, the plow behind us turning up the rich dark earth.

"Is your work hard?" we ask Mr. Mason, as we ride along.

"Not so much work to tire out the muscles; but there's a lot of hard work planning it all and seeing that everything is done right. Look around you as far as you can see. That is all part of my farm — 1000 acres. That means 1000 acres to plow and harrow and plant with seed. Later there are 1000 acres of grain to be cut and threshed and 15,000 bushels of wheat to be sent to the grain elevators and sold. Then I have to keep all the accounts, so as to know how much money I get and how much I spend."



Fig. 11. Twelve acres plowed in one day; the tractor and machine plow do most of the work



Caterpillar Tractor

Fig. 12. One man with a tractor pulling many disk harrows at once

"But surely you must have other people to help?"

"Of course I can't do all that work alone, even with these tractors and machines. I hire several men to work with me all the time from April to August. When harvest comes I get a lot of extra men — you know, the 'harvest hands,' who do the work of the country's harvest from the time it begins in May in Texas until it ends in Canada in late summer.

"I have to be an all-round mechanic too, for these machines will get out of order. I have a good man working for me who can take an engine to pieces and put it together again, and he can do the same with any kind of farm machine. But sometimes I have to do it myself. Yes, a farmer like me has to be a kind of Jack-of-all-trades."

"But, Mr. Mason, your work isn't as hard as the farmer's work years ago, is it?"

"No, I suppose not," says he, looking off over the fields. "In 1870 my grandfather and his boys plowed only 80 acres of this farm with oxen and an old hand plow. First time it had ever been cultivated; for the Indians who lived here in Minnesota did not raise food. That was work! A man and a pair of oxen could turn up just about an acre a day, with aching muscles at the end of it. Fifteen to twenty days of work for one man and four boys to plow an 80-acre field! (Figure 6, on page 11, will show you how Mr. Mason's grandfather plowed.) This tractor and plow will do twelve acres a day, and all I have to do is to sit here and drive it.

"Yes," Mr. Mason goes on; "in those days every-

thing was done by muscles, either a man's or an animal's. For that matter, my own father and I farmed part of this land almost entirely by hand only 30 years ago. We plowed it and harrowed it by tools that were pulled by a horse; seeded it by hand; harvested it with a cradle (figure 13); and threshed it with flails (figure 14)! All hand work! Yes, and arm work and back work too! I remember how tired I used to be after a twelve-hour day. Quite a change has come now that these handy little gasoline tractors and machines have been invented."

Mr. Mason stops the tractor and plow, and we get down.

"Look here, plowing is not the only work that this gasoline engine will do for me on this farm. It will pull any machine that I need to use in raising grain. See that man over yonder? He has just finished his plowing. Now he will hitch on the harrow, which will break the soil into fine bits so that it will be ready for us to plant the seed."

We watch Mr. Mason's helper. In a few minutes he has unscrewed the bolts that fasten the plow to the tractor, has moved up the harrow, and has put the new bolts into place. Then he jumps into the seat, starts the tractor engine, and is off down the newly plowed furrows of the field. Back and forth he drives, never getting out of line. The disks, or plates, of the harrowing machine break up the heavy chunks of earth. After the harrow has passed over it, the soil is soft and smooth.

"But that isn't the only machine," continues Mr. Mason. "Day after tomorrow he'll hitch a seeder on that same tractor, and it will pull him around while he plants seeds in 50 acres of soil in one day! It does it in much better shape than anyone could by hand, too! The soil is plowed straight, with the furrows exactly the same depth and exactly so far apart. The seeds are planted regularly, one for every few inches. My reaper cuts the grain evenly, gathers it into piles of a certain size, and ties it in bundles. The thresher does its work, too. So you see that the machines not only do many times as much work as a man's muscles but do it better."

Mr. Mason seems very interested in telling all the story. He goes on:

"Oh, these newfangled machines are great things, but I never could make my grandfather understand that. He used to laugh at us for using them. Said we ought to train our eyes and our muscles. He used to boast how exact he was; said he could plant a seed every so many inches and never miss! But I know what these machines can do, children. You come back in a few weeks, and you will see a wonderful field of wheat. No human eye, no human arm and hand, no matter how skilled, could plow it and plant it so even. No, sirree! I'm for the machines! I wish Grandfather Mason could have lived to see it. Maybe he would have come to believe in the machine.

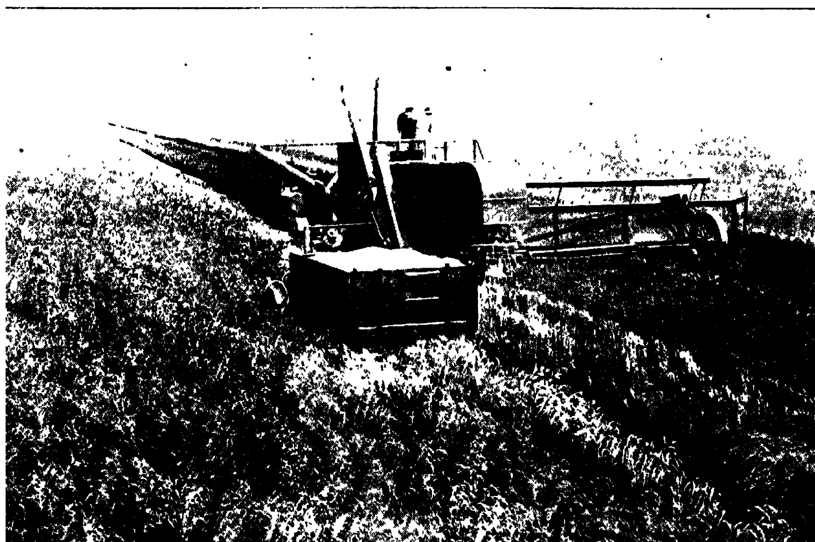
"And I'll tell you another thing. You city folks had better thank your lucky stars we've got machines,



FIG. 13. Mr. Mason's father cut his wheat in 1870 with a cradle



FIG. 14. How he threshed his wheat with a flail



Caterpillar Tractor

FIG. 15. This combine does the work of cutting and threshing which Mr. Mason's father did with a cradle and a flail

because without them we couldn't possibly raise enough wheat or corn or other farm crops to feed you. A whole lot of you would be living on farms raising your own food, as most people did years ago, before machines and engines were invented!"

And then he adds: "Of course my farm's really a small one compared with some. I hear there are farms that have 100,000 acres! Think of it, a million and a half of bushels a year! Well, there is no reason why not. All we need is bigger tractors and reapers and more of 'em. There's no limit to it if the field's level and has no stones."

Later, as we sit at lunch with Mr. Mason in the dining room of his big farmhouse, he continues:

"Well, you've heard about everything but the harvest. All we do now is to let the sun shine on the soil and warm it and let the rain moisten it, and the grain will grow. Then, when the grasses have grown up above my waist and the juice in the berries is white and hard, the wheat is ready to cut.

"Then there's plenty doing on this farm. Come up to the sheds later and I'll show you the 'combine.' That is a single machine that does all the work of harvesting."

With lunch over we go out to the sheds to see the harvesting machine.

"There it is," says Mr. Mason. "Those knives on the side cut a path of grain sixteen feet wide. I drive the machine down the field, and both the cutting and



International Harvester Company

Fig. 16. Harvesting wheat with reaping machines in 1875

the threshing are done while the machine moves along (figure 15). As the grain passes through certain parts of the machine the wheat berries are separated from their shells, cleaned three separate times, and finally left in a tank on the side of the machine. When the tank is full a truckman drives up and takes the grain right from the machine.

"It is then ready to be taken to the grain elevator beside the railroad tracks."

"Tell us more about how your father harvested his wheat in the days before the combines," says someone.

"Well, I suppose when you see this machine way of harvesting, you have little idea of how it was done when I was a boy on this very farm. Father and his boys would go out and swing cradles (figure 13) through the waving grain all day long. Back and forth, back and forth, we went. It took thousands of swings of the big knife to cut one acre of grain. When it was cut, we had to pick it up and pile it, one armful at a time, put it into a wagon, and take it back to the barn. Mother often came out to help (figure 13).

"Then we'd spread the grain on the floor and beat it with sticks to knock the berries from the stalks (figure 14). Seemed as though our work would never end; and yet, for all those backaches, we got only a few bushels of grain out of a day's work!

"Today, with this one combine, we can cut 60 acres in a single day. With the grain threshed and cleaned as the machine cuts it, that means nearly 1000 bushels each day!"



Ewing Galloway

Fig. 17. Farmers store their wheat in grain elevators, such as this one, before it is shipped in freight cars to the flour mills

The Grain Elevator

Mr. Adams has further plans for us, so we drive in his car toward Minneapolis, Minnesota, 50 miles away. On the way we stop at a small town where the Mason wheat is stored in a grain elevator. We walk about in the tall building.

"This elevator holds more than 100,000 bushels," says Mr. Adams. "All the farmers for miles around bring their wheat here every summer. As they bring it in, other men take samples of the grain, test it, and grade it. Later the agents for the flour mills in Minneapolis come here to make their purchases.

"Then long trains of freight cars, made especially

for carrying grain, move in on those railroad tracks. The chutes in the elevators are opened, and the wheat slides down into the cars. When the cars are filled, the chutes are closed, and the train goes away to the flour mills at Minneapolis. Nearly everything is done by machines. A whole train can be loaded in a few hours."

The Second Step: The Milling Corporation Grinds the Flour [1]

We are up bright and early and out at the offices of one of the largest flour mills in the United States. Mr. Greene, the assistant superintendent, is waiting to take us through. As we begin our tour he explains.

Scientists Help To Make Flour

"Flour-making today is not simple; careful study is required for every step of the way. Our work begins back on the farm while the harvesting is going on.

"Remember that the wheat region of our country stretches for 1000 miles from Texas on the south to Canada on the north. Of course the soil and rainfall and temperature are not the same in all parts of this vast area. The wheat seeds that are planted in them are different, too. As a result the wheat berries that are raised in any one region are different from those raised in other regions. Texas wheat is somewhat different from Kansas wheat and very different from Dakota or Canada wheats. Altogether 200 different kinds of wheat are raised in the United States.

[1] We are indebted to General Mills, Inc., for the facts used in this story.

"The miller who grinds the grain into flour must know what kind of wheat comes from each region. So all during the spring, while the wheat is growing, men from the United States Department of Agriculture at Washington find out all they can about it. They travel all over these plains, inspecting the grain, writing down about the climate and soil in each region, and making a record of how fast the wheat is growing. When their reports are ready, they send them to each of our twenty-two mills in different parts of the country.

"The scientists of the milling company study these reports very carefully. From them they can learn something about wheat crops in various parts of the country even before they are harvested.

"Then, when harvest time begins in Texas (the wheat ripens there first because the climate is warmer), our company sends other scientists right into the fields. They take samples of wheat berries from farm after farm and rush them quickly to one of our mills in that region. There the wheat is tested and studied carefully.

"The same thing is done for other regions where wheat grows. As a result the scientists at each mill know exactly about the wheat in their region. Our Texas, Oklahoma, and Kansas mills know how to mix and prepare their special flour. Each of our Chicago, Kentucky, and New York mills and those in Minnesota, Montana, and the Western states know also. All that information is on hand in our offices before the wheat starts rolling in on trains from the harvest fields."

Machines Do Much of the Work

"Let's walk about the mill and see what happens when wheat is ground into flour. First, let's see where the wheat is stored here."

We go outside and walk around the ten cylinder-like bins called storage elevators. They stand 100 feet high! Alongside them are railroad tracks on which the wheat is brought.

"When the grain arrives in the cars, it is sucked up through big chutes into these storage elevators. Each of the elevators holds a special kind of wheat. Notice that especially, because later you will see how important it is to have the various kinds separated."

We leave the elevators and go indoors again. Machines . . . machines . . . machines everywhere! The large rooms seem filled with machinery. Mr. Greene continues:

"Not much like the way your great-grandfathers made flour. They rubbed the wheat berries between heavy stones or let the water wheel turn the old mill grindstones. Here everything is run by electricity, and all the work is done by machines. It is the scientific way.

"First the different kinds of wheat are brought together into one mixture. This is called the 'mill mix.' The wheat runs out in a stream from each round elevator through its own pipe onto a broad moving belt. The mixed wheat is then carried up to the very top of the main mill. Let's go up to that floor."



Fig. 18. The wheat is sent through these big pipes to the storage bins and the cleaning house. This is the first step



Ewing Galloway

Fig. 19. Weighing the batches of wheat before cleaning

In a moment we walk out onto the weighing and cleaning floor.

"Each batch of mixed wheat is now weighed (figure 19) so that we know exactly how much we are mixing and cleaning at one time. First it goes through great sieves and is screened to remove any bits of dirt or different kinds of grain. Then on to the washing and scouring machines it moves (figure 20), where it is beaten by little steel beaters. Finally it goes to the brushing machine, where it is polished until it is perfectly clean. Now it is ready for grinding."

To understand better about the wheat berry, as Mr. Greene tells how it is used, look at figure 24. In that figure is shown a wheat berry about eight times larger than it really is.

"The wheat berry has five important parts. The two outer ones are light and hard; these are called 'bran' and 'middlings.' The inner ones are heavy and soft and white; these are the parts made into white flour. Deep inside, in one corner, is the germ, which, if planted in the ground, will grow into a new wheat plant. The germ spoils the flour, however, so we have to remove it as we grind the wheat.

"Grinding the wheat into flour consists of rolling it and sifting it again and again, separating the different parts from one another."

Mr. Greene points out to us the machines which are doing the work (figure 21).

"The wheat moves in those pipes and runs through the first rolling machine. The rough edges of the rollers



FIG. 20. In these cleaning machines the wheat kernels are scoured and polished



Ewing Galloway

FIG. 21. The wheat next passes through several grinding machines and comes out as a coarse flour

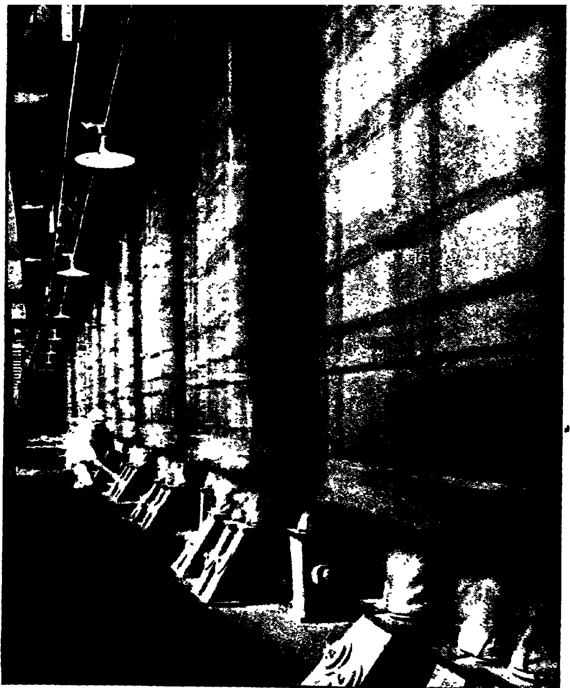
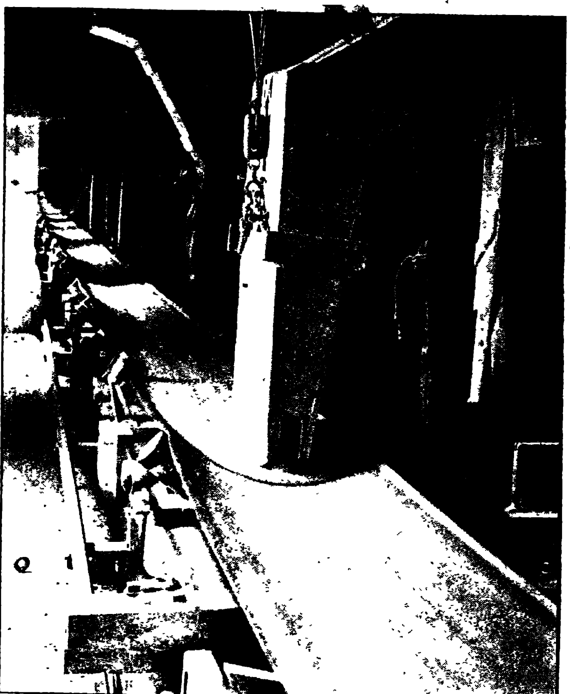


Fig. 22. Sifters like these, where the flour passes through fine silk cloth, often separate it into as many as six different grades



Ewing Galloway

Fig. 23. The flour drops down through chutes and passes along on moving belts

are set so that they will crack the layer of bran on the outside. Then the wheat passes through a sieve. The bran and middlings are left behind and the inside parts pass through. They go through another set of rollers, and the germ is flattened. Next the germ is sifted out through pieces of silk cloth (figure 22). The threads of some of these are coarse, or far apart; others are fine, or near together.

"As you can see, the flour goes through one rolling and sifting after another, becoming finer and finer each time."

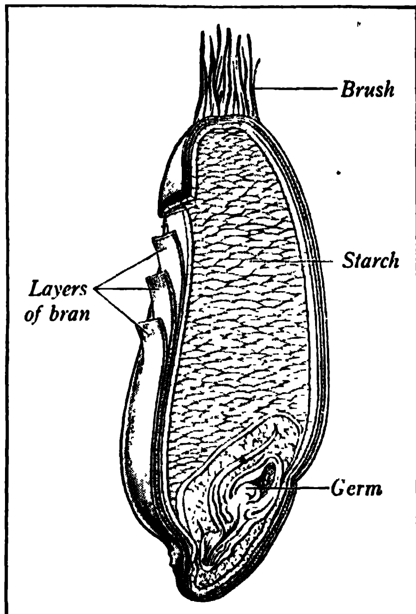


Fig. 24. A wheat berry enlarged about eight times

Gravity Does Much of the Work

"Notice especially how the rolling and sifting machines are arranged. Each set is built lower than the one before it, so that the wheat can *drop* from one to another (figure 23). We don't have to drive a machine or have human hands shift and push and pull it. The pull of gravity does the work without expense. That's why the first step of the work — the cleaning and

weighing — are done on the top floor and the last step is done on the lower floors."

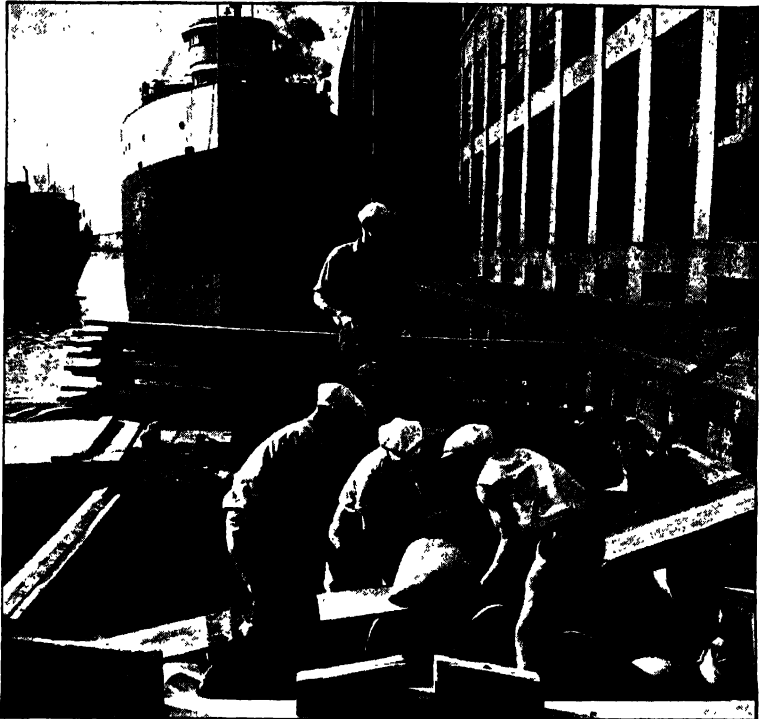
Mr. Greene then suggests that we go down. When we have reached the lower floor, he goes on:

"We have now come to the 'purifier,' where the flour is passed through a current of air which blows away any few bits of bran that may be left. Then the softer parts needed for 'white' bread are sifted through a very fine silk cloth and rolled once more into a white powder. This is the flour out of which your 'white bread' is made.

"One other thing. Each set of machines you have seen here is grinding its special kind of flour. The different grades of wheat come out of their pipes, to be mixed in different ways to give just the special kinds of flour desired. Millions of pounds of flour are mixed in much the same way as your druggist mixes powders for medicines.

"The last thing we do is to put the flour into barrels or sacks ready for shipment. Most of that work is also done by machinery. Even the loading into trains is done by machines!"

"Well, you've seen how wheat is made into flour. If you'll drive over to St. Paul, you can see the last step in making the nation's loaf of bread. A branch of one of the great baking corporations is there. While you are having your lunch here I'll telephone Mr. Hayes, the manager, and arrange for him to show you how 100,000 loaves of bread are baked in a day in one bake-



Ewing Galloway

FIG. 25. These men are loading a Great Lakes boat with bags of flour

shop!" And he adds, as he sees our astonishment, "That's not much like the few loaves your grandmother used to bake in her kitchen oven, is it?"

The Third Step: Baking the Bread

With lunch over, we ride through the twin cities of Minneapolis and St. Paul to the office of the baking company. Mr. Hayes is waiting for us.

The "Geography" and "Science" of Baking Bread[1]

"Come in here and look at my map first," Mr. Hayes says. "To understand bread, you have to know some science and some geography!"

"Science and geography in breadmaking! What do you mean?"

"I mean that we don't take just 'any old' flour made from 'any old' wheat grown on 'any old' farm to make our bread. We turn out 100,000 loaves a day here, and each loaf has to be as nearly as possible like every other loaf. Why, one of these ovens holds in one batch enough bread for a whole town! You can imagine how much that requires of all the things which go into the making of bread. The corporation of which this bakery is a part uses the following things in one year:

3,000,000 barrels of flour	25,000,000 pounds of milk
60,000,000 pounds of sugar	11,000,000 pounds of salt
10,000,000 pounds of eggs	9,000,000 pounds of yeast

"To make sure that each batch is just right, we must know exactly how much flour, how much milk, how much sugar, and other things to mix together to make bread. We must know how long to let them stay in the mixer and at what temperature to put the dough in the oven and how long to bake it. Do you see that in order to make what we think is the best bread we must do it scientifically?

[1] We are indebted to *The Story of Bread*, by the Continental Baking Corporation of New York, for the facts used in this story.



FIG. 26. This flour will be weighed and mixed with milk, yeast, and other things to make a batch of bread



Ewing Galloway

FIG. 27. Pouring the flour, milk, and other things into the mixing machine

"As you already know, the kind of wheat depends upon the climate of the region where it grows. So it is with flour; flour also depends upon geography.

"It has taken our scientists many years of experimenting to get our loaves of bread healthful and to the people's taste. They have tested and tried many kinds of milk and yeast, salt and sugar, just as carefully as they have flour. As a result, your mother knows that when she says to your grocer, 'I want some White's Wrapped Bread,' she will get today exactly the kind that she got last week. Scientific knowledge and machines have made that possible.

"Yes, breadmaking is very different today from what it was in my grandmother's day," explained Mr. Hayes. "She did it all by hand and mostly 'by eye.' She took out a scoopful of flour from a barrel, sifted it through a hand sieve, added a little butter for shortening, some salt and yeast, and either some water or milk. Next she stirred and stirred it in a big mixing bowl and then kneaded it back and forth on a smooth breadboard. To make enough dough for two or three loaves of bread would take, perhaps, half an hour. Then she would put the dough into a tin and leave it in a warm place to 'rise'; that is, to expand. Ten or twelve hours later she would knead the dough again until it was as small as before, cut it into loaf sizes, put it into the pans, let it rise once more, and then bake it in the oven of her kitchen coal stove for about an hour.

"Let us see how the bread is made in this bakeshop.

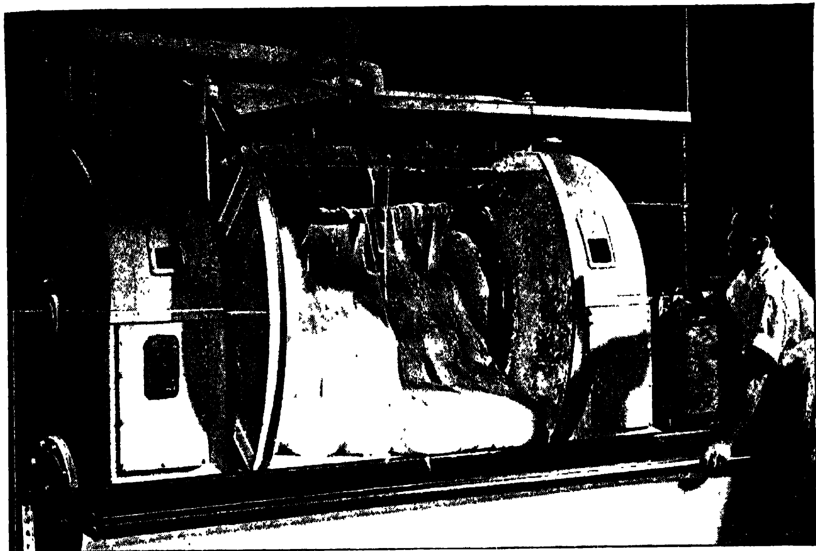
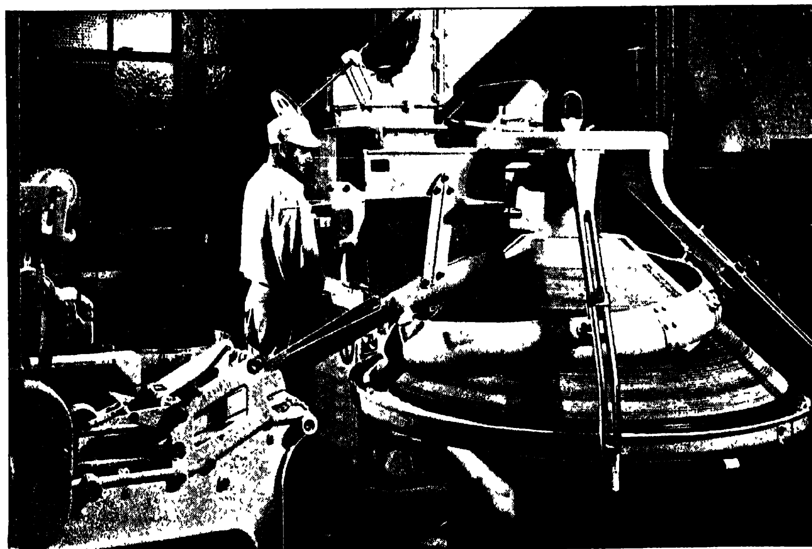


FIG. 28. When the dough is mixed, it is turned out into these long troughs for rising



Ewing Galloway

FIG. 29. This machine forms the dough into round balls

"*First.* We weigh in those containers exact amounts of flour, milk, salt, and other things needed for one batch of bread (figure 26).

"*Second.* These are poured into a huge mixer (figure 27) and turned round and round by power until the dough is of just the right temperature and 'thickness.'

"*Third.* The dough is then poured into long metal troughs (figure 28) and moved into a warm room to 'rise.' The rising room is kept at the same temperature all the time.

"*Fourth.* The dough stays there for a certain length of time and then slides down the chute into the dividing machine. (Do you see that gravity again does the moving?) As the dough passes through the machine it is cut into pieces, each piece being of a certain weight.

"*Fifth.* The pieces travel on to the 'rounding' machine (figure 29), which makes them into round balls.

"*Sixth.* They go to the molding machine, which shapes them into loaves and drops each loaf into a pan. The pans move up at just the right moment on a moving belt which is ready to receive them.

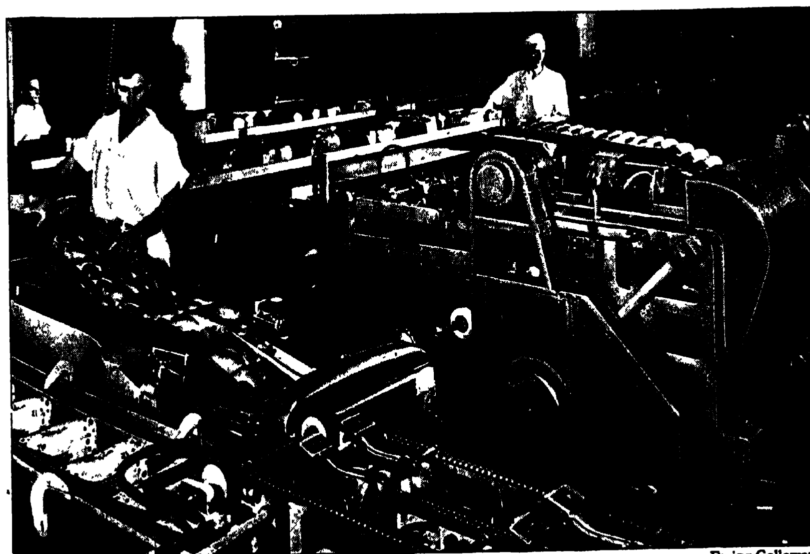
"*Seventh.* The pans continue to move on another belt to a room where they again stand a certain length of time to rise.

"*Eighth.* They are pushed into a huge oven (figure 30) where they are baked at a temperature of about 450° F. for a certain length of time.

"*Ninth.* When the loaves are baked they are emptied onto racks to cool. Then they travel along to



FIG. 30. A hundred thousand loaves a day are baked in ovens like this



Ewing Galloway

FIG. 31. This machine wraps the loaves of bread as they move along

another machine (figure 31), which wraps them and puts on a seal at the same time. They are now ready for the trucks, which take them to stores, restaurants, and homes all over this city and near-by towns."

That Is the Story of the Nation's Loaves of Bread

Did you get from these stories a glimpse of the many kinds of work that people do to make the millions of loaves of bread needed each day by the American people? Let us gather up once more some of the principal things we have learned that help to make this possible.

First. Engines and machines have taken the place of the muscles of millions of human beings. Tractors pull the giant plows and harrows, seeders and harvesters, that prepare the soil, plant the seeds, and harvest the grain. Locomotives pull the grain to the elevators and mills. Engines make the steam or electricity that gives the power to run the grinding rolls and sieves of the flour mills. Engines run the mixing and measuring and baking machines. Engines move the trucks that deliver the loaves of bread all over our country.

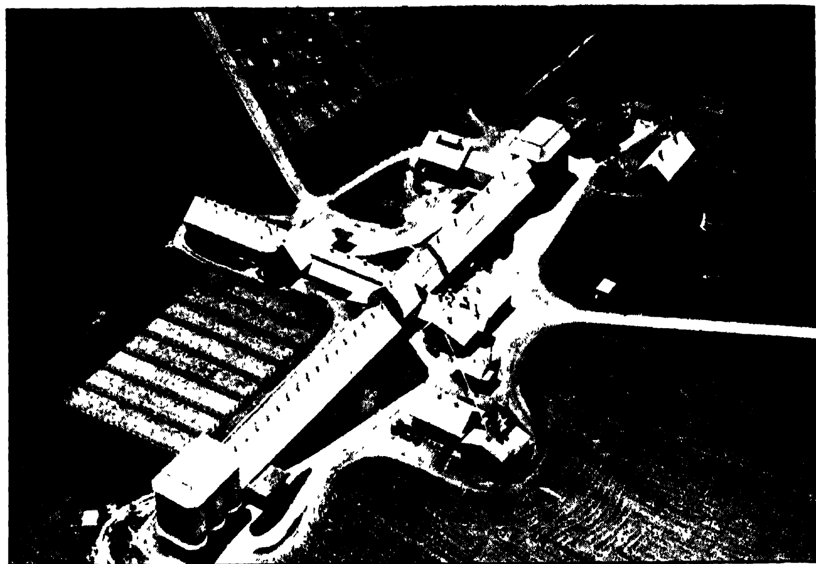
In the actual making of bread, machines have been so arranged that most of the work is done without using human or animal muscles. Engines move things either on endless chains or on moving belts. The force of gravity is used too. One machine is placed lower than another so that things drop or slide down from one step of the work to another.

Second. With the help of science, millers and bakers have learned about the grain and all the other

things which have to do with breadmaking. It helps them to keep the flour mills and bakeries clean as well as to know how to mix things exactly.

Third. All these things are made possible by large companies. They have large amounts of money and can build huge factories and power stations, set up costly machines, hire thousands of workers, buy raw materials in "million lots," and the like. This great wealth makes possible what we call large-scale manufacturing; that is, making things in million lots with giant machinery. It makes it possible to hire scientists to collect facts and to experiment carefully; to hire engineers to build factories and experiment with machinery; and so on. Finally, it makes it possible to have one company own many different kinds of businesses and carry them on all together even in many distant parts of the country. In other chapters of this book we shall learn much about "corporations" and how they work.

These three things, then, working together, make it possible for more than half the American people to live in cities and towns and do manufacturing and carry on businesses while a few million farmers raise the crops and other kinds of food which the city people must have.



National Dairy Products Corporation

FIG. 32. An air view of a modern dairy farm



United States Department of Agricultu

FIG. 33. A herd of fine Holstein cows

CHAPTER III

A Picture Story of Milk

IF YOU live in a city or town, this is probably what happens every morning. When your mother or the cook goes to the kitchen to prepare breakfast, she opens the door, and there, in the hallway, is a bottle of fresh milk. Day in and day out, the year round, this is true; in any part of the country — north, east, south, or west. It matters not whether you live on the twelfth floor of an apartment building in a large city or in a one-family house in a residence town: there stands the bottle of milk, pure and fresh every morning.

How does it get there?

Do you own a cow? Probably not. If you live on a farm or in a near-by hamlet, your family may "keep a cow" and milk her every day. There are about 6,000,000 families in our country who do that. But there are nearly four times as many families who live in towns and cities. These 22,000,000 families cannot raise cows.

How does it happen, then, that a bottle of fresh milk is delivered at the door every morning? The answer to that question is the "story of a bottle of milk." For this story we shall not go on a sight-seeing trip as we did with the loaf of bread; instead we shall use pictures. Look at the pictures and read the descrip-

tions in the order in which they are arranged. They will tell the story.

The story of milk could begin at any one of America's millions of small farms. If it did, one picture would show a few cows grazing in the pasture; another would show them being milked at evening in the cow barn. A third would picture the farmer driving the cans of milk to the village station in the morning.

But this story of the way milk is prepared for the cities and towns begins at one of the many great farms of a dairy-products corporation. In figure 32 we have an airplane view of the farm, and below it one of the smaller herds of cows.

We begin with the milking. The cow is brought to the "milking parlor," which, like everything connected with the preparation of milk, has to be spotlessly clean. The cow's flanks, udder, and tail are washed. Then the workman attaches the milking machine to the udder (figure 35). The machine is started, and the milk is drawn out into a large glass container which stands on a weighing scale. When all the milk has been drawn out and weighed, it passes through a clean pipe to the cooling and bottling room across the road (figure 34). There it flows into a huge tank which is surrounded by ice and is cooled to about 40° F. If the milk is not to be pasteurized, it passes from the tank through little pipes into clean bottles in the bottling machines. It is now ready for delivery.

The milk comes from the farm to these country receiving stations, where it is first inspected. If the milk

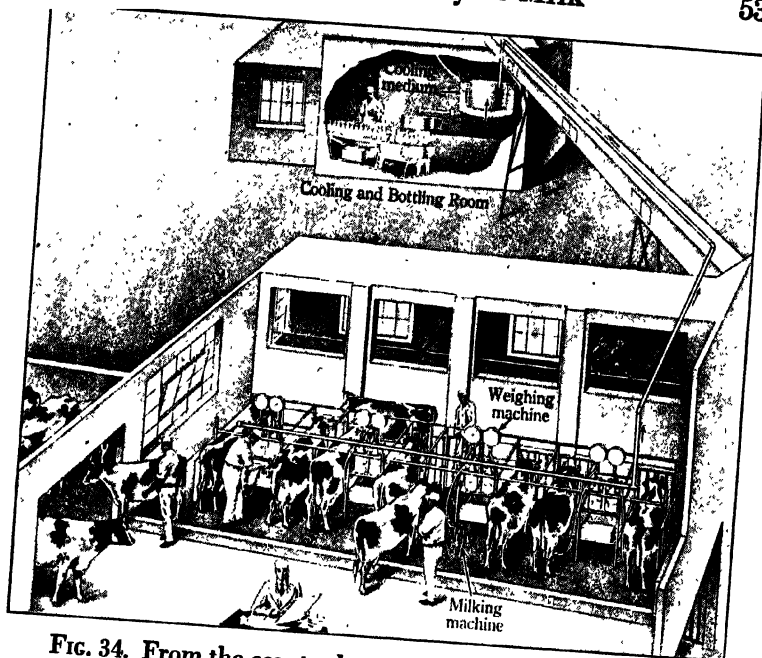


Fig. 34. From the cow to the milk bottle in one diagram[1]

is to be pasteurized, it is drawn off into ice-cooled motor tanks (figure 36) and sent to the processing plant in the city. These tanks are really giant thermos bottles.

At the city plant the milk is drawn off into huge clean tanks and heated to a temperature of 143 degrees for 30 minutes (figure 37). Then it drops down into ice-cooling machines, where it is kept at a temperature of 40 degrees or lower.

[1] The rest of the pictures in this chapter are from the National Dairy Products Corporation.

Fig. 35. Milking cows with machines

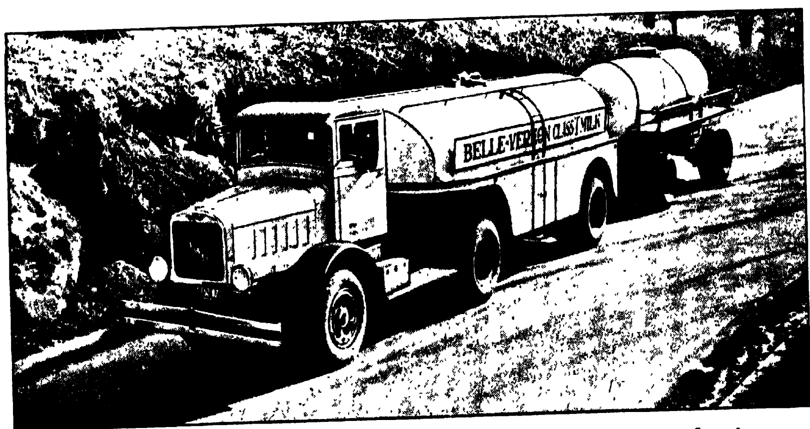


Fig. 36. Tank trucks rush the milk to the processing plant in the city

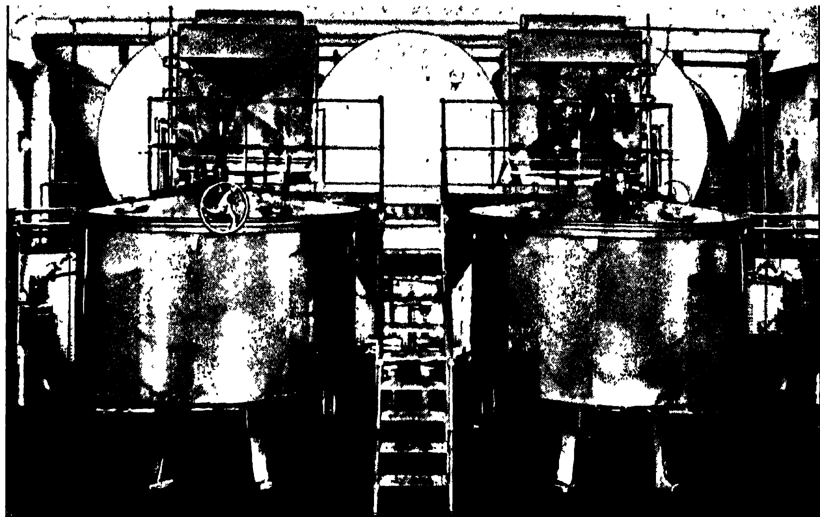


Fig. 37. These pasteurizing tanks heat the milk to 143 degrees for half an hour. The milk is then rapidly cooled and kept at 40 degrees or lower

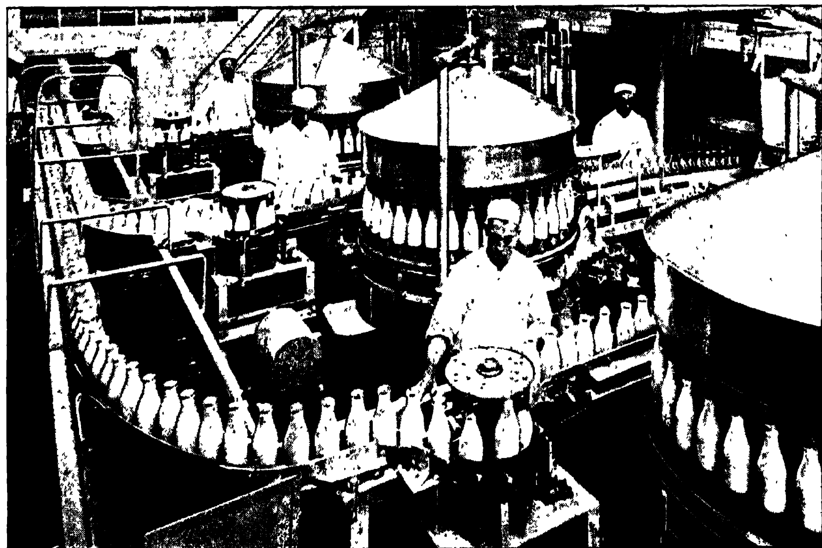


Fig. 38. Filling and capping the milk bottles by machines



FIG. 39. Even the caps are put on the milk bottles by machines

From the cooler it drops into the milk bottles (figure 38). As fast as the bottles are filled, they move on a traveling frame and pass under another machine which presses a cap onto each one (figure 39). Everything is done by machinery; no human hands touch the bottles.

Figure 40 shows how each milk bottle is scrubbed, brushed, and sterilized in hot water for 30 minutes each day before being cooled and filled.

Finally, very early in the morning, every day in the year, the deliverymen pack the bottles of milk into the ice boxes of their wagons or autotrucks and go from house to house, from apartment to apartment, leaving the bottles of fresh and pure milk at people's doors.

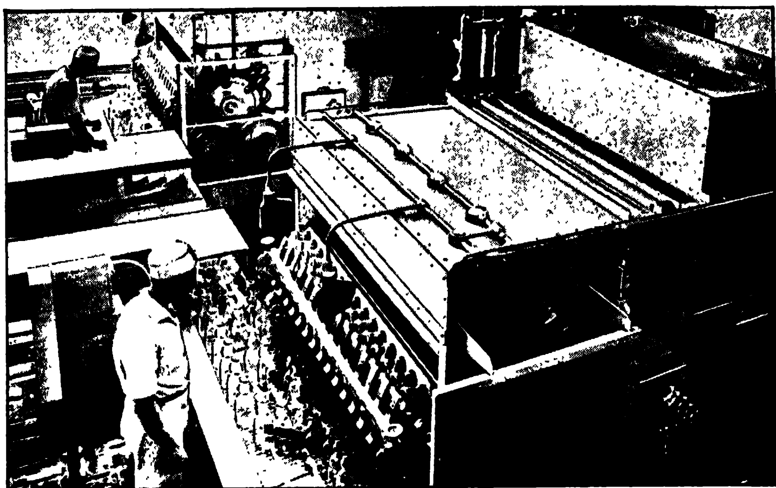


FIG. 40. Washing milk bottles by machine

Milk Has Long Been One of Man's Best Foods

As far back as history can tell us, the milk of cows (and of other animals too) has been used as a food for human beings. It is at least as old a food as "bread" made from grain, and perhaps it is older than bread. Scientists have found on the walls of caves in Spain drawings of cows that they think were made by artists at least 20,000 years ago. On buildings made in Babylon 5000 years ago there are carvings showing men milking cows. India, Egypt, and other ancient regions have also left records which tell us that cows' milk was used long, long ago.

We shall not be surprised to learn, therefore, that almost the first white explorers to step on the soil of North and South America brought cows with them. In

the 1500's De Soto and Coronado and other Spaniards left some of their cows behind them as they explored the southern part of what is now the United States. The English and Dutch settlers of the early 1600's brought cows in their little ships. In those days of settling the continent, hardly a farmer was without a cow, and one or more trudged along with every wagon train of pioneers as it moved westward across the land.

As settlements grew up all over the land, every farmer raised a cow or two for milk and cream and for the butter and cheese which were made from the milk. So it was that on the farms of the frontier each family supplied its own milk. But as more and more people went to live in towns, they had to buy milk from those who stayed in the country. So, for 100 years and more, farmers' boys drove their wagons into the villages every morning, delivering the milk taken from their cows the night before.

That plan worked well enough for small places, and is still the way it is done in many towns. But when the towns grew into cities, some other way had to be found to provide enough pure milk every day for the tens of millions of city people.

For many years scientists and engineers and business men worked with the farmers to find such a plan. In the 1800's they organized large dairy companies. In every region of our country where there are cities, one or more of such companies supplies the people with their milk.



A cow like one in the cave drawings of 20,000 years ago

The cow was man's friend in Babylon 5000 years ago



The Pilgrims brought cows to America

Each pioneer family took a cow with it

Fig. 41. For thousands of years man has depended on the cow



Ewing Galloway

Fig. 42. A traveling dairy in Buenos Aires. Milking the burro at the customer's door

Summing Up the Story of the City's Milk Bottle

From the picture story of milk we can understand why fresh milk can be delivered to our kitchen doors every morning of the year. It is chiefly because the work is organized by a large company which is called a corporation. With its wealth this company can buy huge farms near each of the larger towns and cities. It can buy herds of fine cows and take good care of the pastures. Everything can be done on a large scale, which means that things can be bought more cheaply than if they were purchased in small quantities.

The materials to work with are also of the finest kind. There are machines for making everything spotlessly clean, machines for milking, and machines for cooling the warm milk as it comes from the cow. Large



Ewing Galloway

FIG. 43. Women of Brünn, Czechoslovakia, deliver milk in dogcarts to the city

numbers of tank cars carry the thousands of gallons of milk to the cities. Huge heating machines, bottling machines, washing and sterilizing machines, make it possible to pasteurize all the milk that is brought to them. This company can hire thousands of skilled workers to run these machines and to drive its trucks and delivery wagons.

Another important thing which this company with its great wealth can do is to build laboratories and employ scientists to make experiments. It can get the very latest scientific information about milk and everything connected with the work of preparing it for use.

All the work is possible, of course, chiefly because of the use of machines which are run by giant engines and which can do much more work than men can do by hand.

Books You Would Like To Read

ALLEN, N. B. Geographical and Industrial Studies. Ginn and Company, Boston.

ALLEN, N. B. *Our Cereal Grains.* Ginn and Company, Boston. *The story of some of our grains; how they are raised and prepared for use.*

CARPENTER, F. G. *How the World Is Fed.* American Book Co., New York. *How foods are produced and prepared; visits to the food centers, markets, factories, farms, forests, and the seas.*

CASSADY, CONSTANCE. *Kitchen Magic.* Farrar & Rinehart, Inc., New York. *The history and geography of foods as well as the story of how they are used and prepared.*

CHASE, A. E., and CLOW, E. *Stories of Industry, Vol. II.* Educational Publishing Company, Boston. Corn, wheat, and meadow grass; milk, butter, and cheese; meats, fish, whale fisheries.

CRISSEY, FORREST. The Story of Foods. Rand McNally & Company, Chicago. The story of the foods that come into our retail stores, telling where they come from and how they are prepared and used.

NATHAN, MRS. A. G. The Farmer Sows His Wheat. Minton, Balch & Co., New York. The growing of wheat in America from earliest times to the present.

WELLS, RHEA. An American Farm. Doubleday, Doran & Company, Inc., Garden City, New York. Two boys who lived in the hills of Tennessee before the days of automobiles.

WILDER, MRS. LAURA. Farmer Boy. Harper & Brothers, New York. Upper New York of about sixty years ago is described by a boy of nine who wanted to do everything his father did.

PART III

Clothing Our People

HOW many workers do you think had a part in making and selling your suit or dress? Two or three? Five? Ten? Fifty? More than a hundred?

How many helped in bringing to you your shoes? your gloves? your overcoat? your hat?

Perhaps if you had been asked that question before you studied how Americans get their food, you would have answered, "Oh, two or three or half a dozen, at the most." But now what is your best estimate? Fifty? Probably many more than a hundred! Perhaps several hundred!

Yes, several hundred different persons helped in one way or another to make any one of the things you wear. The story of each piece of your clothing is as long and complicated as that of a loaf of bread. It begins with a farm; with growing things. It ends with clerks selling the suit or the dress to you in a retail store. Between the two are hundreds of people who have worked and earned their living doing some part in the making of that piece of clothing. Men and women in factories and mines, in railroads and trucking companies, in stores and offices, — a whole army of people, — helped in some way.

In Part III we shall read some of the story of our clothing. We do not have space to tell it all here, so we shall take one example — cotton. As you read the story, however, you can think to yourself: "About the same kinds of things happen in the making of other kinds of cloth. This is really the story of how people get their clothing in a country like ours."

CHAPTER IV

The Story of Cotton Cloth

IF YOU turn through any of the books in this series, you will notice that the peoples of the earth today clothe themselves in many different ways. In *Nature Peoples* you saw that hundreds of tribes, like the Bushmen of Africa and the Papuans of New Guinea, wear almost no clothing. Their homelands are in tropical regions, where it never becomes really cold, and they have not felt the need of clothing.

Many People Use Animal Skins for Clothing

There are other nature peoples who live in such cold lands that they have to wear clothing to keep from freezing. Recall the Ona and other tribes of Tierra del Fuego, or the Eskimos and other peoples who live in the Far North. What do they use for clothing? The skins of animals. The Copper Eskimos make suits out of thin deerskins for summer and out of heavy sealskins for winter. With their copper knives and scrapers, their needles of bone and "thread," they cut and scrape and sew the skins into garments. Very warm and very good-looking they are, too, as you can tell by figure 44.

The nature peoples are not the only ones to use animal skins for clothing in cold weather. On the streets of any American or European city you can see women

and even men wearing fur coats during the cold season. And as the pictures of *The Building of America* show, the settlers on every frontier of our country depended on animal skins for much of their clothing — coats and trousers, shirts and caps, boots and gloves.

Most Peoples of the World Use Cloth for Garments

But as you look at the pictures of *Peoples and Countries* you see something very different. The people in those lands have learned more comfortable ways of living than the nature peoples or the pioneers. For one thing, their clothing is generally made of some kind of cloth. Figure 44 shows some examples. Among the Asiatics notice the long white cotton gowns of the Indians, the cotton coats and trousers of the Chinese, the cotton blouses of the Russians, the flowing cotton kimonos of the Japanese. Even the shoes are made of cloth. Among the British, French, Spanish, Italians, Germans, Slavs, and other Europeans, shirts and dresses, trousers and coats, all are of cloth.

Which Cloth Clothes the World?

What kind of cloth is generally used? Of several kinds — cotton, wool, linen, silk, and others — what do most of the peoples of the world use?

Think of our American clothing. Most of it is made of cotton. Your shirt, your dress, your underclothes, probably your stockings, are of cotton. What about your heavy winter suit or overcoat? It may be of wool, but very likely it is partly of cotton. Of course



Fig. 44. Peoples of the world use skins and cloth for their garments

many Americans wear some things of silk or wool or linen, but nine tenths of our people are clothed in garments of cotton.

The proportion is even higher in Asia. Nearly 450,000,000 Chinese, 350,000,000 Indians, 70,000,000 Japanese, and untold millions of Filipinos and other Asiatics wear little but cotton clothing. So you see that in Asia alone, where there are half the people of the world, cotton is very important. If we add to these the hundreds of millions in Europe, Africa, and the Americas whose clothing is made largely from cotton, we can say, indeed, that "cotton clothes the world."

We wish there were space to tell the story of many kinds of cloth that are used for the garments of the world. Since there is not, we have chosen cotton, for the reason that it is so important to the peoples of the entire earth. Let us begin with a piece of cotton cloth.

Seeing a Piece of Cloth through a Magnifying Glass

One glance through the magnifying glass and you exclaim: "Why, cloth is just threads which cross one another in certain ways!" Exactly so. Look closely and notice how the threads hold one another together (figure 46). The threads that go one way pass first under one line of the threads going the opposite way, then over the next line, under the next, over the next, and so on — under and over, under and over. This arranging of the threads under and over is called "weaving."



FIG. 45. Cotton fibers magnified 80 times

FIG. 46. Cotton cloth magnified

Now get several other pieces of cloth, being sure to have a very coarse cotton and a very fine one and count the threads in each. Lay a foot rule on the cloth under the magnifying glass and measure one inch. Is the number of threads the same for both? No, the coarse cloth will have very few, perhaps 30 or 40 threads in one inch; the fine one will have many more, perhaps 80 or 100 in one inch. Why is this? Because the threads of the fine cloth will be smaller, so that more will be required to make an inch.

No matter how many threads are required, a piece of cloth is made of threads woven together.

But what are threads? They are twisted, or "spun," fibers, or hairs, of cotton. Each fiber is so fine that you can hardly see it with your own eyes. Try to get


Ewing Galloway

FIG. 47. Picking cotton by hand

some raw cotton and study single fibers of it through the magnifying glass. If your glass were strong enough to magnify a fiber 80 times, it would look like that of figure 45.

"Why, the cotton fiber is flat and partly twisted!" you say.

"Yes; and notice that it has a 'kink' in it, too. Many of the single fibers are twisted, or spun around and around each other, until they form one tight, strong thread. The twists make it easier to spin them, and the 'kinks' help to hold them tightly together."

"So a single cotton thread is many of these tiny fibers twisted tightly together?"



Ewing Galloway

FIG. 48. Picking cotton by machinery

"Right!"

"And a piece of cloth is simply many threads woven over and under one another?"

"Right again!"

"Then how are the spinning of the thread and the weaving of the cloth done?"

The best way to answer that question would be to take a trip and see with your own eyes a cotton plantation and a mill. But most of you cannot do that; so we have given the picture story of figures 49–54 to show you the chief steps in the work. Imagine that you are on a tour in a cotton mill where the bales of cotton have arrived.



Ewing Galloway

Fig. 49. One of the machines for loosening the cotton

First. The bales of loose cotton, weighing 500 pounds, are opened and "picked" by several machines known as breaking machines (figure 49). The first of these loosens the cotton a little, the second a little more, the third still more and so on until the fibers are all loosened and flattened. After it has been picked, the cotton fills twice as much space as it did in the bale.

The yarn of one bale, if the fibers could be tied together end to end, would be 5000 miles or more in length. After being picked, the fibers are left tangled in every crisscross way. So they must go on to other machines.

Second. These millions of tangled fibers are now carded, or combed, into straight hairs. The flat masses of cotton are run through rows and rows of wire teeth



Ewing Galloway

FIG. 50. The ribbonlike slivers are coiled in cans

in a series of "carding" machines. They come out as ribbonlike "slivers" and are then coiled in cans (figure 50). A man runs the machine, but the machine does the work.

Third. Each sliver now passes through a number of rolling machines, which draw and straighten it. The slivers change to "laps" and are passed through drawing rollers. Each time these laps go through the machines the fibers are made straighter than before. The finer the cloth is to be, the more machines the cotton must pass through. During this period the cotton is again passed through the combing machines, which further straighten the fibers.

Fourth. After the cotton has been combed, drawn, rolled, and twisted on a number of machines, it comes



Saco-Lowell Shops

Fig. 51. The spinning machines

to the roving frame, which still further twists it, so that it will be ready for spinning into thread.

Fifth. The yarn now comes to the spinning machines (figure 51). Again it passes between rapidly turning rollers; again it is straightened and stretched; and then, finally, it is whirled quickly through a "flying ring," which twists it into a strong thread. It is this thread that is woven into cloth. Notice how few people there are. Thousands of whirling spools, or spindles, of yarn are tended by a few girls!

Sixth. To be put into a warp for weaving in a loom, the threads first have to be wound on spools (figure 52) and placed on frames called "creels" (shown in figure 53). Machines, of course, do that — machines tended by a few workers.

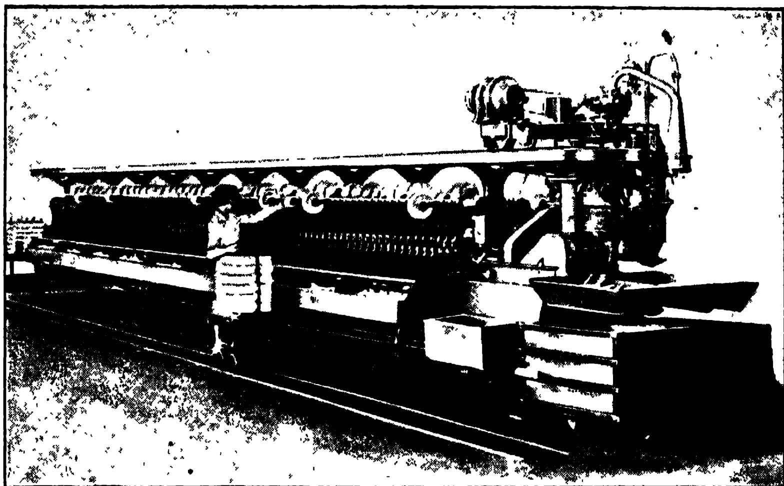
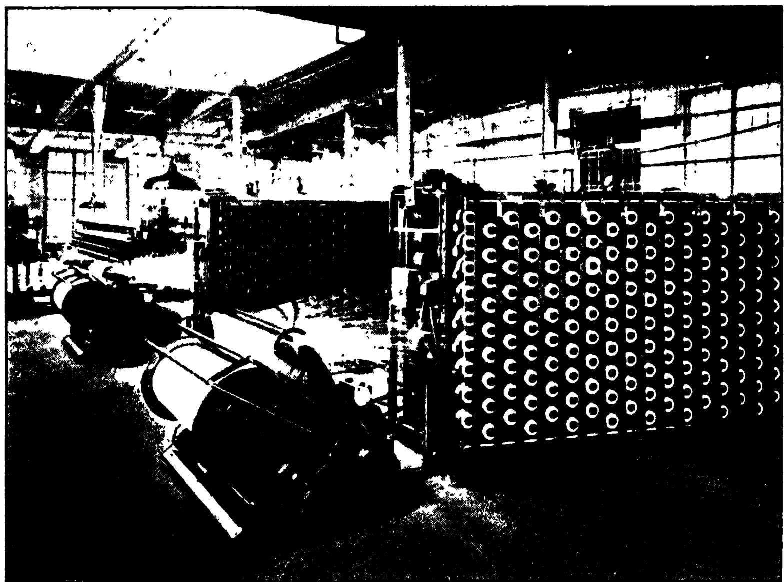
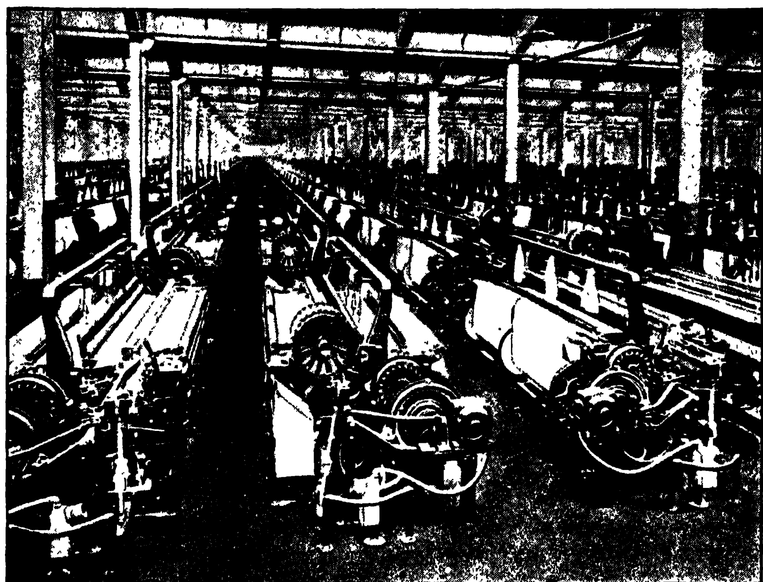


Fig. 52. Winding thread on spools



Barber Colman Company

Fig. 53. Threads from the creel being wound on the beam



Draper Mechanics Corporation

FIG. 54. The weaving machines

Seventh. From the creel the threads are drawn onto a large roller (figure 53) and laid in exact order side by side, a yard or more in width. This roller, which is called a "beam," is placed in the loom ready for weaving.

Eighth. The last step in making threads into cloth is the weaving. It is done on looms like the ones above. The large roller (the beam) on which the threads have been drawn from the creel is put underneath, and the threads are run through five wires, which separate them regularly. These threads (the warp) are raised and lowered alternately so that a shuttle carrying the woof thread can be driven between them by the power that runs the loom. Before 1738, when Kay invented the

"flying shuttle," the shuttle containing the bobbin of thread had to be thrown through by hand. This was a very slow process. During the past two centuries so many inventions have been made that now one weaver can operate twenty-five or even more looms at once.

You can see, therefore, how many kinds of work must be done before the cotton is ready to be made into garments. There are too many kinds for all of them to be remembered, but five steps are most important:

First, the raw cotton is cleaned and combed and drawn out into a broad, flat "lap."

Second, the fibers are spun into threads called "yarn."

Third, some of the threads are arranged as "warp" on the loom; others are wound on spools, or bobbins. They are then ready to be woven on the looms.

Fourth, the "woof" threads are woven in and out through the warp threads, making "cloth."

Fifth, the cloth is cleaned, bleached, dyed, and printed. It is then ready to be made into garments or other useful articles.

Making Cloth before the Days of Machines

Can you imagine how different was the making of cotton in the days of your great-great-grandfather before people had those giant machines to help them? In April and May the fields were plowed and harrowed and planted by hand. The weeds were chopped out week after week with a hoe by hand. The cotton was picked by hand, cleaned by hand, packed in bales by hand, carded and spun by hand, and woven on a hand

loom. Finally the cloth was cut and fitted and sewed by hand to give the finished garment.

The picture of figure 47 gives just a glimpse of how the cotton was picked. Slow and tiring work it was! To produce an acre of cotton required nearly a month of hard labor. Not more than 60 or 70 pounds of cotton could be picked in a day, a few yards of yarn could be spun, a yard or two of cloth could be woven.

That was the way cloth was made in your great-great-grandfather's day.

In Ancient Times

And that was clothmaking 5000 years ago too! Who was the first to discover that cotton fibers could be twisted into yarn and woven into cloth we do not know. In the semitropical climate and rich irrigated soil of the Nile valley in Egypt people have grown and used cotton for several thousands of years. Even today this is one of the world's important cotton-growing regions. In parts of Asia, too, ancient peoples depended on cotton for many of their fabrics. Historians tell us that at least 5000 years ago the Chinese had learned how to spin and weave cotton. Almost as long ago the people of India knew it also. Some of the very old Indian books tell of making "kurpas," their name for cotton, and their religious writings of 1500 B.C. describe fine cloths made of it.

It is believed that the knowledge of how to use cotton was brought long ago from these Asiatics to the peoples who lived around the eastern end of the Medi-



Margaret Bourke-White

Fig. 55. This woman is tending bobbins on a machine in a factory for making lace in Moscow, Russia

terranean Sea. Certainly we know that the business men of Phoenicia and Greece, Rome and Carthage, carried on a valuable trade in cotton cloth. From these peoples of the Near East the knowledge of how to use cotton slowly spread to the tribesmen of western Europe about 1000 years ago.

By 1200 and 1300 A.D. merchants of Venice and other European trading cities were importing cotton cloths from India. These cloths were called "calicuts" from the name of a small trading city on the western coast of India. Perhaps you have heard your mother speak of buying a cheap kind of cotton cloth called "calico." In the old days, however, "calicuts" were not all coarse cotton cloths. Some were made of very finely spun yarn and were so perfectly woven that they felt like silk in one's hands.

It was in this way — slowly, very slowly, through 1000 years and more — that knowledge of cotton and its use spread over the earth. But many more years were to pass before the people of England, France, Germany, and the other newer countries of Europe invented hand spinning wheels and looms to spin cotton fibers into yarn and make it into cloth.

Long, Long Ago Cotton Grew Wild on Most of the Continents

How did these ancient peoples who lived in the warmer lands learn to grow cotton and make cloth from it? We do not know. We only know that before people knew how to plant cotton seeds and to grow

their own cotton, they found the cotton growing wild. Not only as low bushes did it grow, but as tall trees. Because of this some peoples called it "tree wool." Even today the German word for cotton is *Baumwolle,* which means "tree wool."

Tens of thousands of years ago wild cotton could be found on every continent that had a tropical climate. It grew in northern Africa, in parts of Asia, on the islands of the Pacific. On his first voyage to the west, in 1492, Christopher Columbus found wild "cotton trees" in the West Indies and on the mainland of South America. Coronado and other Spanish explorers discovered it growing wild along the Rio Grande and in the semi-tropical lands of what is now Louisiana and Texas. Cortes and his followers found the Aztecs of Mexico using the wild cotton to weave lovely cloths. Magellan saw it in Brazil, and Pizarro found it being made into cloth by the Inca peoples of Peru.

So perhaps for many thousands of years the peoples of tropical lands lived surrounded by wild cotton. Exactly when they began to pick it from the trees and use it in their homes we do not know.

When and how they found out how to sow the cotton seeds in the ground and grow the plants, we do not know. The beginnings of "cotton farming" are indeed completely lost to us. We can only guess how some "bright" man may have noticed tiny cotton plants growing near the tall cotton trees. Perhaps he finally guessed that they came from the seeds that dropped out of the plants each year. No doubt a good many

such "bright" men made the same guess in different parts of the earth and at different times. And finally someone discovered that the seeds could be sowed each year and would grow up into new cotton plants.

The story of how all that may have happened, and how, after many more thousands of years, people learned to spin and weave the cotton fibers on machines, cannot be told here. In *Mankind Throughout the Ages* you will read the story more fully.

Books You Would Like To Read

ALLEN, N. B. Cotton and Other Useful Fibers. Ginn and Company, Boston. The story of many of our fibers.

CARPENTER, F. G. How the World Is Clothed. American Book Co., New York. How the materials for our clothing are made and prepared.

CHASE, A. E., and CLOW, E. Stories of Industry, Vol. 2, Part II. Educational Publishing Company, Boston. Leather, shoemaking, horsehides.

MACBRIDE, SARAH, and MCGOWAN, E. B. Fabrics and Clothing. The Macmillan Company, New York.

MCGOWAN, E. B., and WAITE, C. A. Textiles and Clothing. The Macmillan Company, New York.

NYSTROM, PAUL H. Textiles. D. Appleton-Century Company, Inc., New York.

PRYOR, W. C., and PRYOR, H. S. The Cotton Book. Harcourt, Brace and Company, Inc., New York. A photographic picture book with a story.

SCARBOROUGH, DOROTHY. The Story of Cotton. Harper & Brothers, New York. A story with pictures and maps.

TOOTHAKER, C. R. Commercial Raw Materials: Their Origin, Preparation, and Uses. Ginn and Company, Boston.

TURPIN, E. R. H. Cotton. American Book Co., New York. The history of cotton; telling of its use and manufacture in ancient times and in Europe and America.

PART IV

Builders in Iron and Steel

Iron vessels cross the ocean,
Iron engines give them motion;
Iron needles northward veering,
Iron tillers vessels steering;
Iron pipe our gas delivers,
Iron bridges span our rivers;
Iron pens are used for writing,
Iron ink our thoughts inditing;
Iron stoves for cooking victuals,
Iron ovens, pots, and kettles;
Iron horses draw our loads,
Iron rails compose our roads;
Iron anchors hold in sands,
Iron bolts, and rods and bands;
Iron houses, iron walls,
Iron cannon, iron balls;
Iron axes, knives, and chains,
Iron augers, saws, and planes;
Iron globules in our blood,
Iron particles in food;
Iron lightning-rods on spires,
Iron telegraphic wires;
Iron hammers, nails, and screws —
Iron everything we use.[1]

[1] Educational Publishing Corporation, New York and Chicago.

TODAY everyone knows what iron is, for, as the poem shows, it is everywhere in our lives. Iron . . . iron . . . iron all around us. We live in a world of iron.

But it is not as iron that we know all these things today. It is as "steel" that we use many of them. The iron has been made into steel.

Do you remember how many of the things mentioned in the stories were made of steel? Mr. Mason's tractor, his plow and harrow, and parts of his threshing machine, and his trucks were of steel. The grain elevator and the giant machines in the flour mill were mostly of steel. The ships and railroad cars which carried the wheat or flour to different parts of the country were made of steel. The machines for mixing bread and doing the other work of breadmaking were of steel. Do you think it would easily be possible to grow grain on our vast farms, grind it into flour, and make it into bread without steel?

Think of the way milk was pasteurized, bottled, and transported. Could these things be done in the same way without machines of steel?

The story of steel has several parts. It begins with the story of iron and ends with things which are made of steel. In the next chapters we shall tell:

First, what iron is and how it is mined.
Second, how coal is mined and made into coke.
Third, how iron is made into steel.
Fourth, how machines and engines are made out of steel.

CHAPTER V

Iron-Mining: The First Step in the Making of Steel

How Iron Appears in the Earth

As you have gone about in the countryside near your home have you ever noticed that clay banks or rocks by the side of the road are often of a somewhat reddish color? It is iron that gives that red color to the soil.

Nature has been favorable to man in giving him large supplies of iron. Only three things are found more often in the surface of the earth. If you think of the land part of the whole earth, nearly one twentieth of it is iron.

Do you remember from *Peoples and Countries* that in Europe there are rich fields of iron in Germany and France, in Spain and Sweden? In Asia iron deposits are to be found in Russia and China, as well as in other parts of the continent.

In our own country, especially in the Southern states, there is so much iron in the soil that the whole landscape is tinged with red. In Minnesota, about 80 miles from the west shore of Lake Superior, is one of the richest iron fields in the world. So much iron lies in the earth there that it can easily be dug without going very far below the surface. Fifty years ago these vast iron

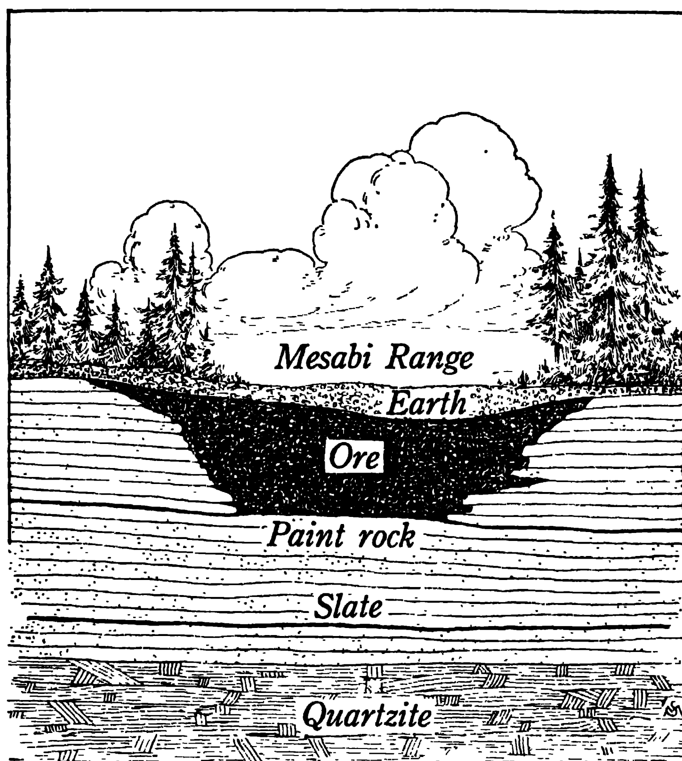


FIG. 56. The iron ore in the Mesabi Range lies near the surface of the earth

hills were discovered by a daring pioneer named Merritt. Today they are known as the Mesabi Range (figure 56).

Our story of making steel begins at the Mesabi Range. Let us imagine that we have gone to Duluth, Minnesota, by train and from there to the iron fields by automobile.

Mining Iron Ore on the Great Mesabi Range

"Well, we're here at last," says our guide, the mining engineer. "Let's get out and walk over to the mine."

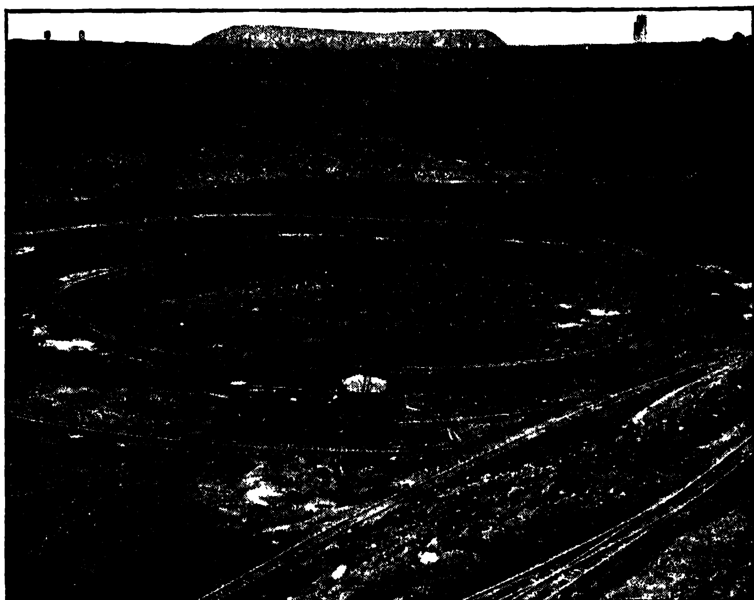
Across the fields we go for a short distance. Suddenly we stop in astonishment. There, before us, is an enormous hole in the ground. "Hole" is hardly the word for it; "valley" or "canyon" would fit it better. We step back from the edge. "Like the Grand Canyon," we think out loud.

"Yes," says the engineer; "but there's a difference. Nature's rivers wore down the Grand Canyon through ages of time; but men dug that hole, and they did it in just a few years! That is the largest iron mine in the world. Half the iron used in the United States comes out of a few holes like that!"

"How could human beings dig such a huge valley in a few years?" we ask, scarcely believing what the engineer has said.

"They did it because they had several things to help them: dynamite to blast out the rock, steam shovels to dig it out, and railroad tracks and trains and giant engines to carry it away. And, don't forget, giant power to run the machines. Do you see them below?"

"Yes, engines and machines," we reply, as we look down. Here and there steam shovels are moving, each one on its own railroad track. On a track just below us is a train of open cars.



Ewing Galloway

FIG. 57. The huge hole that men have dug in their search for iron in Minnesota

As we speak the shriek of a whistle cuts the air. Men run in all directions. . . . *Bang!* There is a terrific explosion, and a cloud of smoke rises from the steep side of the valley.

"That blast of dynamite broke off hundreds of tons of ore."

"Ore!" we say. "It looks like soft earth!"

"It does, but it's iron ore. Feel it," the engineer says, stooping down to pick up a handful.

"Can this be iron ore — this soft, reddish soil?"

"Yes; you know iron is not found as a pure metal



Ewing Galloway

FIG. 58. A powerful steam shovel picks up two tons of ore and dumps it into a waiting car

in the ground. It is mixed with rocks and gravel and other things. The mixture is called iron ore.

"There are whole hills and valleys of it here; this is the most valuable deposit in the world. The ore is richer than is that of Alabama; richer, too, than that of the Saar valley, on the border between France and Germany."

We turn to watch a steam shovel (figure 58) which stands alongside the hill that has just been blasted by the explosion. The engineman in his driving-box moves it on the track, close to the ore. With a screeching and

clanking of machinery, the shovel dives into the loose ore, picking up two tons of it with a single bite. Now the long steel crane, on which the shovel hangs, swings around in a great half-circle. The engineman moves another lever; the shovel opens at the bottom, and into the open railroad car drop the two tons of ore. Then back swings the derrick and down dives the shovel. Up it comes with two more tons of ore. Around it swings again, and the ore is dumped into the car.

The engineer looks at his watch. "Twenty seconds for that bite," he says. "One minute for three bites. In five minutes the car is full. Thirty tons of iron ore have been dug and loaded into a car in five minutes!"

No wonder that 30,000 tons of iron ore can be dug out of that mine in one day; for we can see more than a dozen steam shovels, each digging at the same time, each filling its own train of open cars. At each one is a gang of men laying railroad tracks ahead on which the shovel machine can run.

For several hours we sit on the edge of the man-made canyon watching the mining of iron ore go on. Of all the industries we have seen so far, this is the most interesting. Such power and such strength in those steam shovels! What a difference between their biting up two tons of ore at a time and a man with a little hand shovel! And steel! Everything is made of steel! Will these engineering wonders never stop?

"What happens to those trains of ore?" we ask.

"They go out of that opening in the mine, down the hill beyond, and over to the docks at Duluth on Lake

Superior. There the ore is loaded into lake boats and taken through the Great Lakes to steel mills in different parts of the country. Let's go over to the docks."

Two hours later we are at the harbor of Duluth. More wonders of engineering! One of the ore trains we have just seen loaded at the mine runs on its track high up over the pier. The train stops; the bottom of the car opens; and, with a roar, the ore drops straight down into bins that have been arranged below the tracks.

We look down at the pier below. A long steel boat with huge holes in its deck has moved up beside the dock. Slanting chutes are then lowered from each ore bin to the holes in the boat's deck (figure 59). Suddenly, with a loud crash, thousands of tons of ore slide down from the bins into the holes. In a short time the entire boat is loaded. Then it steams quietly out of the harbor into Lake Superior.

"That's what the use of machinery can do!" says our engineer. "Imagine the number of men we would need to dig ore by hand shovels and throw it into that boat! It would take days and days to load a single boat. We couldn't send enough ore to keep the steel mills running if we depended on hand labor, not even if we used thousands of men.

"And did you notice that the ore slid *down* from the piers to the bins and *down* from the bins to the deck of the boat? The force of gravity as well as the machines did the work."

"Where does the ore boat go from here?" we ask.

"To the steel mills, where the iron in this ore is made into rails and engines, autos and trains, beams and bridges. The biggest mills are near the Appalachian Mountains, but there are others on the shore of Lake Michigan near Chicago."

"Why are they there? Why don't they build steel mills here, near the iron mines?"

"There are several reasons. Let's go down to my office on the docks, and I'll show you a map that will explain it."

A few minutes later we gather around the big map which hangs on the wall in the engineer's room.

"To separate the iron from the rock materials in each ton of iron ore, about one and one-half tons of coal, in the form of coke, and one third of a ton of limestone are needed. A ton of iron ore takes up less space in a boat than the same amount of coal or limestone. So it's cheaper to ship the iron ore to steel mills built in the coal district than to ship the coal to the iron. The big coal fields are found in the region from Illinois to Pennsylvania. Another reason why steel mills are in the northeastern section of our country is that it's the region where the most steel is used and where transportation is best.

"So, for various reasons, the big steel companies have built most of their mills in that section. You can find steel mills in Illinois near Chicago, in northern Indiana, in Detroit, in Cleveland, in Pittsburgh, and in other places. This region, as I think you already

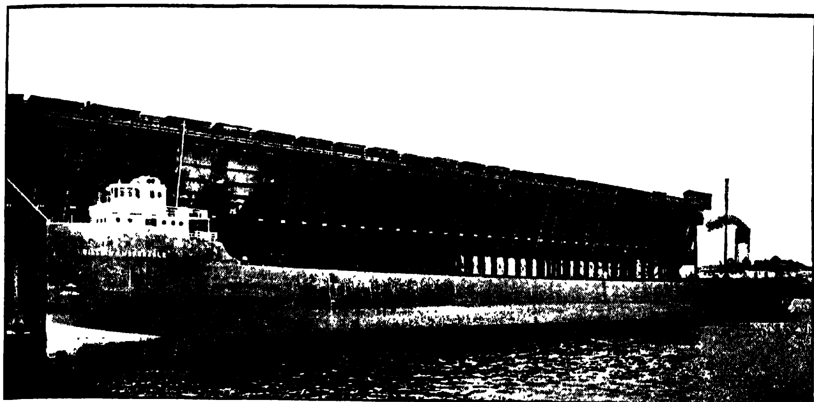


FIG. 59. Long steel boats like this one carry ore to the steel mills

Ewing Galloway

FIG. 60. Unloading the ore from the boats at the steel mills

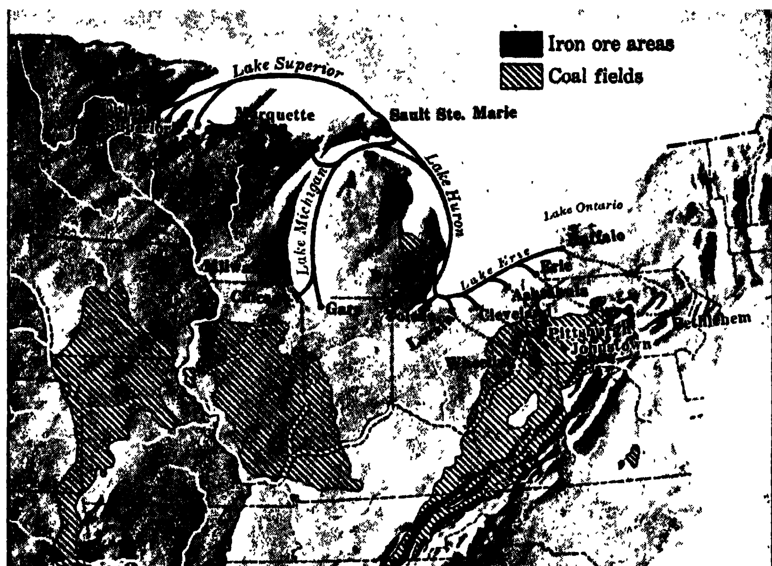


FIG. 61. The lines through the Great Lakes show the routes by which iron ore is shipped from the Minnesota region to the steel mills of Pennsylvania, Ohio, Indiana, and Illinois. On the return trip the boats carry coal to the people of the Northwest

know, has become the industrial region of our country. Steel-manufacturing is perhaps the biggest business of all the many that have located there."

This glimpse of mining the iron ore on the Mesabi Range and shipping it to one of the mills of a steel corporation shows you the first step in steelmaking.

Since coal is so very necessary, too, let us go on to the picture story of coal in Chapter VI. This will show us how coal is mined and made ready for its part in the making of steel.

CHAPTER VI

A Picture Story of Coal

How Coal Formed in the Earth

DO YOU remember something of the story of coal from *The First Book of the Earth*? If you do, you know that coal formed in the earth millions of years ago. The scientists think that it might have happened in this way:

The earth is old — one billion years, two billion years, or more. Those who study the formation of the rocks do not agree upon the exact age, but they do agree that the earth is very, very old. We can be sure that long, long ago it looked very different. At one time it was like a huge ball of gas and melted matter whirling in space. It was hotter than any heat of which we can think. As the earth gradually cooled, a crust formed on the surface. The high spots on this crust became land and made the continents of the earth. In the lower places water collected and formed the oceans. While the earth was so very hot, there was no life on it; but as it grew cooler, living things began to appear.

The climate was damp and hot. There was much low, swampy land, and great forests grew rapidly. After millions of years these swamp forests were again covered by water and crushed down by rocks or thick layers of soil. After more millions of years other forests grew up

in the same places. Again and again this same thing happened. The tree trunks and large branches were packed down into a hard layer. The forests grew up, then died and were buried. These layers of trees and other vegetation buried in the earth changed in many ways and formed the coal that we mine today.

Three Different Kinds of Coal Were Formed

1. *Anthracite, or "hard," coal*

During the millions of years when coal was forming, the crust of the earth was pushed up again and again into great mountains of rock and soil. Layer after layer of dense vegetation and forests was pressed down and buried in great folds. As the millions of years passed, these buried forests became *anthracite,* or hard coal. Anthracite burns slowly and makes little smoke. It is much used for cooking and heating. Cities that burn anthracite are likely to be clean cities.

2. *Bituminous, or "soft," coal*

During these same years some of the layers of buried vegetation were not very hot and were crushed only by the rocks just above them. Layers of this sort became *bituminous* coal. This coal is much softer than anthracite. It contains much oil, gas, and tar, and burns very easily, but it makes a heavy black smoke. Bituminous coal is the fuel that makes most of our factory wheels turn. It is used by railroads and ships and central power stations. In manufacturing cities, such as Chicago and Pittsburgh, where huge amounts

of soft coal are burned, there is much black smoke. In the Middle-Western states bituminous coal is even burned in the furnaces of homes, but because of its smoke housewives do not like to use it. The Eastern states are less troubled by smoke, for they burn more anthracite.

3. *Lignite, or brown coal*

Lignite is still softer than bituminous coal. It was formed from vegetable matter which had been pressed less hard than either anthracite or bituminous coal. It has a woody appearance and is light in weight. It contains much water and will not burn so well as either hard coal or soft coal. A ton of lignite produces only about half as much heat as a ton of bituminous coal.

There is still another kind of coal; but the three that we have named — anthracite, bituminous, and lignite — are the chief kinds. A ton of the best coal produces several times as much heat as a ton of the poorest. So you see that it is necessary, when speaking or thinking of coal, to tell what kind you have in mind.

Now let us learn something about the mining of coal. Study the pictures on the following pages and read carefully what is written about them. They will give you much of the story.

The miners in figure 62, safety lamp on hat and dinner pail in hand, are just leaving the hoist, or cage,



Fig. 62. These miners are just leaving a mine after hours of work below the ground

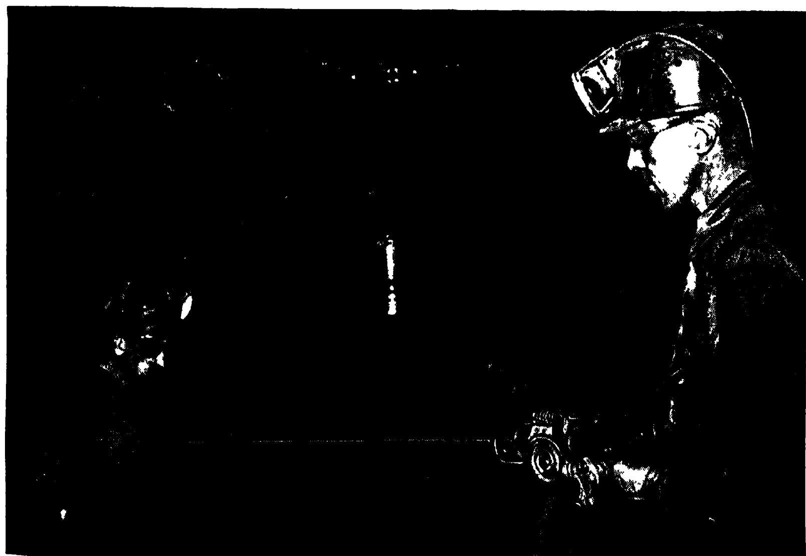
which brought them up from the mine. Let us see in imagination what they were doing before they came to the surface.

Figure 63 shows us four of them. In one of the small rooms, or chambers, of an anthracite mine an explosion of dynamite has just blasted loose some of the coal. The two miners in front are shoveling out the pieces. The two men at the back are testing to see whether they must put up wooden posts to keep the



Rittase

Fig. 63. It is hard work shoveling the broken coal into the cars



Ewing Galloway

Fig. 64. Electricity helps the miner to cut away the coal

ceiling from falling. The explosion sometimes weakens the ceiling so that posts are needed before the miners can work there safely.

Before the man can blast the coal out, however, a place must be made in which to put the dynamite. This is done with an electric mining machine, and is called undercutting the coal. The man who is running such a machine in figure 64 is called the cutter. The other man, who is the helper, is called the scraper. The scraper is removing the fine coal, called bug dust, as fast as it is cut down by the teeth of the machine. This machine cuts a deep gash. Then the coal above is blasted down.

In figure 65 we see two miners pushing an empty car out of the cage toward their room. There they will load it with the coal they have broken out. The hardest work which miners in many mines do is loading the cars. The roof of the room where they work is often so low and uneven that they cannot stand up straight but must bend over in order to get the coal.

Tracks are laid along the entries, or passageways, and into the rooms where the miners work. After a car is loaded, it is added to a trip (or train) of coal cars and carried along the entries and up in the cage. Up to the present time the mule has always been used for pulling the cars. In most cases he never goes aboveground, but in mines today where electricity is used he is no longer needed. Small electric locomotives made especially to use in the mines haul the trains of coal to the hoist. The cars, and the miners also, are brought



Fig. 65. When the cars are filled with coal they are put into the cage and raised to the surface. Then the cage brings down empty cars for the miners to fill again

to the surface in cages which are raised by means of a cable wound on great drums, or spools.

Below, in the mine, the miners put a little check in each car to show who mined the coal. Each man is paid for the amount he mines. The weigh boss weighs each carload to see how much the miner will receive for his work. The check weighman also sees that the weight of the coal is put down correctly, so that the miners will be paid for all that they have mined.

Until the coal is brought aboveground, hard and soft coal are handled in much the same way, but the buildings at the mouth of an anthracite mine are entirely different from those at the mouth of a bituminous mine. At a bituminous mine the coal cars are hauled up a raised track, and at the top the cars are tipped and emptied into the building where the coal is screened, or separated, into two sizes — lump and slack.

Railroad tracks are often laid under the building; and after the coal is screened, it is shot down from above into the cars and started on its journey.

In the anthracite mine the coal is carried up an endless chain of buckets to what is called the breaker house. Can you find these in figure 67? They are on the incline which leads from the ground to the top of the breaker house. In the house itself is a machine known as the breaker (figure 68). The anthracite coal is carried up to the breaker. In the breaker great machines clean and break the coal and then separate it into sizes (figure 69). There are nine of these sizes. Five of the sizes — broken, egg, stove, chestnut, and pea — are used to heat houses; the others are used in heating the boilers in factories.

Chutes carry the coal of various sizes and dump it into the cars, which stand under the breaker ready to receive it.

Near every mine are trains of coal cars ready to carry the coal which will warm and light homes, run factories, and keep the trains and steamships moving (figure 70).

FIG. 66. This man is an engineer who runs the machinery for carrying the coal up to the breaker house



Rittase

FIG. 67. The breaker house. Here the coal is broken up and sorted

How Our Lives Depend upon Coal

Our picture story has shown the chief things that miners do to bring the coal out of the earth so that it can be used by the people of our country. Do you know what happens to it after it leaves the mine? Have you ever thought what an important part coal plays in our lives?

More than five tons of coal are mined and used each year for every man, woman, and child in the United States. One of these five tons is used for heating houses and for cooking. Surprising as it may seem, much of the other four enters our homes in ways that we do not think of when we think about coal. It comes as power on electric wires, through water pipes, and in various ways through the kitchen door.

One man estimated that he and his family used in a year fourteen and a half tons of coal which no member of the family ever saw and which were never inside his coal bin. He had in mind, of course, all the things that were done for them outside their home. For example, more than a ton of coal was used each year at the power station to make the electric current that lighted their house and heated the toaster on the breakfast table and the iron with which their clothes were pressed. Almost a ton of coal was used at the power station to make their ice. Eleven tons were needed to produce their supply of gas for cooking and heating. A small amount was burned in the city pumping plant that pumped water to their home; another ton was needed



Rittase

Fig. 68. Coal going into the breaker, where it will be broken into different sizes. The men are picking out pieces of slate or other things which are not coal

to mill the flour, to bake the bread, and to refine the sugar which the grocer delivered at their door. Almost everything of theirs made use of the burning of coal.

Coal is burned in the making of nearly all our manufactured goods. One and one-half tons of coal were used for every ton of iron in our railroad cars and rails, our automobiles, our bridges, and our skyscrapers. To make the paper in this book, twice its weight in coal is needed. Part of the money that you pay for the clothes you wear and for much of your food goes for



Rittase

FIG. 69. This machine is screening the coal as it comes from the breaker and sending each size of coal to its own place

coal, for they were made in coal-burning factories and were transported by coal-burning trains and ships. Although we do not see the coal that goes into the production of all these things, we must not forget that without it we could not have the comforts and luxuries which many of us do have today. "King Coal" still rules us today, for his power still turns most of our engines.

The Steelmakers Turn Coal into Coke

Coal is not always used in the form in which it comes from the earth. Many years ago those who were work-



New York Central

Fig. 70. Outside the mine you can always see long lines of freight cars filled with coal waiting to be sent to all parts of our country

ing with the making of iron in England learned that if they made "coke" from the coal, the fires would be much hotter.

What is coke? We can define it best by telling something of how it is made. If coal is slowly heated in an oven where there is no air, we may obtain from it ammonia, gas, tar, and oil. When these things are taken out, hardened black pieces of carbon which we call "coke" will be left. This coke will make a much hotter fire than the same weight of coal.

As the big steel companies began to mine their own iron ore and coal, they decided that it would be

cheaper to build coke ovens near the coal mines and make their own coke.

So today at their mines, when the coal is brought up the shaft of the mine, it is loaded into little trains of cars. The cars are then run out on tracks over a long line of "beehive" coke ovens. At one of these mines 900 such ovens are going day and night. The coal is dumped from the cars through openings in the tops of the ovens. Then the openings are sealed except for a crack about an inch wide, and the coal is burned for two days. At the end of that time the door is opened; a machine for unloading goes in, picks up the coke, and loads it into cars to be taken to the steel mills some distance away.

Other Things Made from Coal

After some time it was discovered that only about two thirds of the coal burned in the oven became coke.

What happened to the other third? Was it wasted? For many years it was, although coal-owners and engineers complained of this waste. Engineers tell us that in 1913, valuable products worth $72,000,000 went up in clouds of smoke from the beehive ovens of America.

For a long time people did not know that in those clouds of smoke were riches almost as valuable as the coal itself. But, after 1800, scientists learned that many of these were very useful. Out of them they began to secure the "by-products" which we know today.

Great plants were built for this purpose. Here the smoke is led from the ovens through huge pipes and

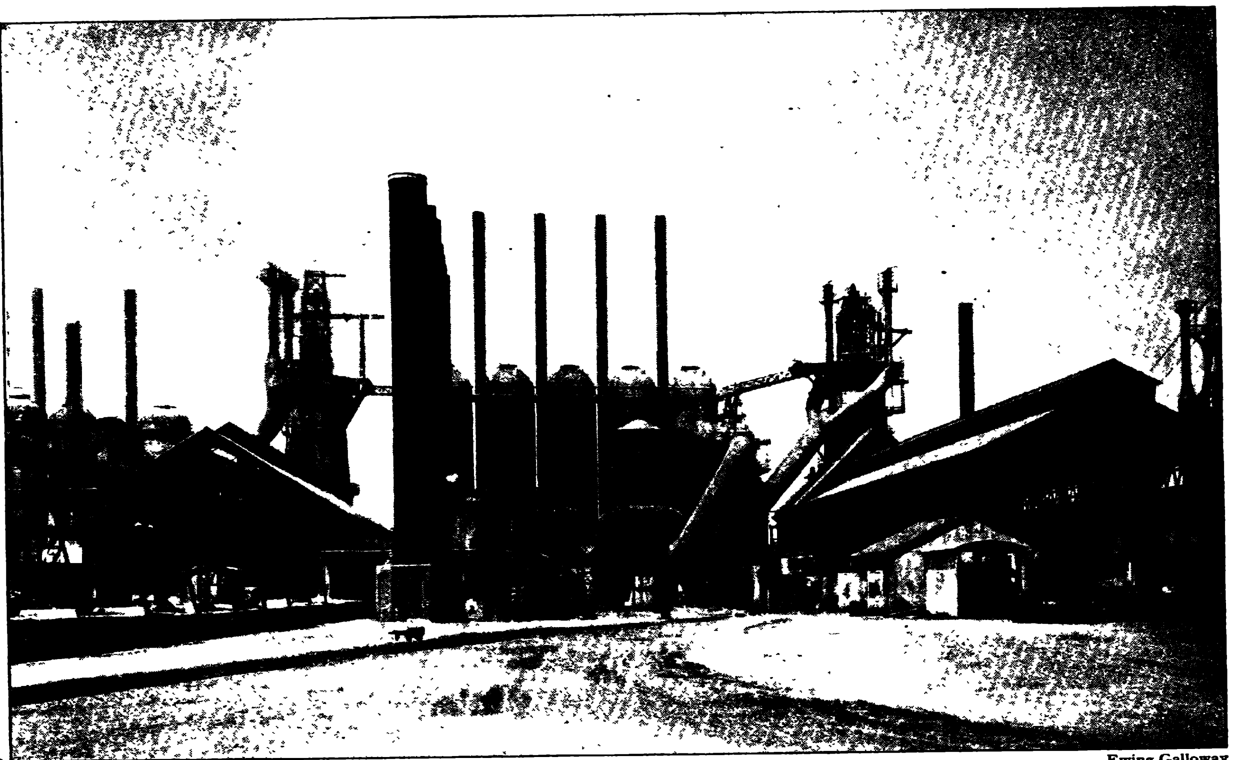
treated in various ways. One part of the plant gets tar out of the waste smoke. Another turns some of the waste into ammonia. Still others give us crude oil. Today one ton of coal (2000 pounds) makes:

1425 pounds of coke	7.1 gallons of tar
10,500 cubic feet of gas	2.4 gallons of crude oil

Nor is that all! The coal tar itself is now changed into many valuable things. This sticky black matter becomes dyes for cloth; delicate perfumes; fertilizers; medicines and drugs, such as Novocain, which dentists use to deaden pain. These are only a few of the by-products that are now made from coal. Later you will study about many of the most important ones.

All these examples are a good illustration of what science can do for us. It was the scientific way of doing things that taught us how to make these by-products. To most of us coal is just coal; to a scientist, however, coal is a substance that contains many different things — wonderful and valuable things. We shall see later how science plays an important part in other industries.

As we continue and study about the way steel is made, we shall see that one of the most important things a steel company does is to mine coal and manufacture coke. It may own thousands of acres of coal land; it may hire tens of thousands of miners and other employees to dig the coal, clean it, and transport it to the furnaces where it is made into coke.



Ewing Galloway

Fig. 71. General outside view of a steel mill

CHAPTER VII

Making Steel and Things of Steel

Steelmaking Is a Giant Industry

YOU REMEMBER that iron ore is usually a mixture of iron and other things. Only about half the ore which we saw scooped out of the Mesabi hills was iron. The rest was rock and materials other than iron. To make steel, it is necessary to remove the oxygen with which the iron is combined and the impurities.

About 600 years ago ironmakers learned that a way to separate the iron from these other things was to heat the ore with carbon (in the form of charcoal) in a very hot fire. The iron would melt and run out as a liquid. In Chapter XV we shall read the story of man's long, long struggle to learn how to make the fires hot enough and the furnaces big enough. But learn they finally did, and the result today is the blast furnace. The blast furnace is, indeed, the big stove of all industry. The huge stacks in which the air is heated for the furnace stand 100 feet high and are 20 feet in diameter. The rooms of the steel mill spread over acres and acres of land (figure 71).

Let us take a trip through a steel mill to get a glimpse of how steel is manufactured. Some steel mills are outside of Pittsburgh, near the Pennsylvania coal

fields; others are along the southern shore of Lake Michigan at South Chicago, Illinois, and at Gary, Indiana; still others are at Cleveland and Youngstown, Ohio.

Into each of these mills, day and night, boats and trains are pouring a steady stream of iron ore, scrap steel (old, worn-out things of steel), coke, and limestone. We can hardly imagine the huge amounts in which they come. For example, 65,000,000 tons of ore were moved from the Minnesota iron fields in the year 1929. That is enough to fill a train of freight cars, each holding 50 tons, which would stretch from New York City across the United States and out over the Pacific Ocean to the Hawaiian Islands! And all of that ore must be mixed with large amounts of coke and limestone! Perhaps you can see now that steel-manufacturing is really the giant of all the big industries today.

Making "Pig" Iron in the Blast Furnace

Mr. Thompson, one of the engineers, guides us through the steel mill, pointing out just a few of the important things. Of course we do not expect to remember all of them, but hearing them and getting pictures in our minds will teach us much about man's work in making steel today.

As we walk outside by the five tall round buildings, the engineer says: "That first circular building is a furnace 90 feet high and 25 feet thick. In it we make 550 tons of pig iron in a 24-hour day. Long ago ironmakers learned to pour the melted iron out of

their little furnaces into trenches of sand, where it hardened into bars. These bars were called 'pigs.' We still call them that, although they are made in a different way today.

"Most of the impurities have been removed from the ore, but pig iron still contains carbon, manganese, phosphorus, sulphur, and silicon. We'll see later how these are taken out and how some are put back again with just the right amounts of each needed to make good steel.

"Before we go any farther, here is a simple diagram that I have prepared for you (figure 72). It will show the main steps in the preparing of pig iron and in the making of steel. Each of you may have one to refer to as we go along. I think it will help you to understand better what is done in the making of steel.

"Now notice how nearly everything is done by machines and how we use gravity to help us whenever we can. The trains of iron ore, coke, and limestone are run in on those tracks up there (see *A* in your diagram), and the materials are dumped into bins, from which they are loaded in proper amounts onto hoist cars (at *B*), to be taken to the top of the blast furnace (*C*).

"Here a layer of limestone, then a layer of iron ore, and then a layer of coke are dropped into this furnace. This is repeated until the furnace is full.

"Now for the fire which melts the iron ore and limestone. We use coke, you know, because it gives a much hotter fire than coal."

"How hot is it, Mr. Thompson?"

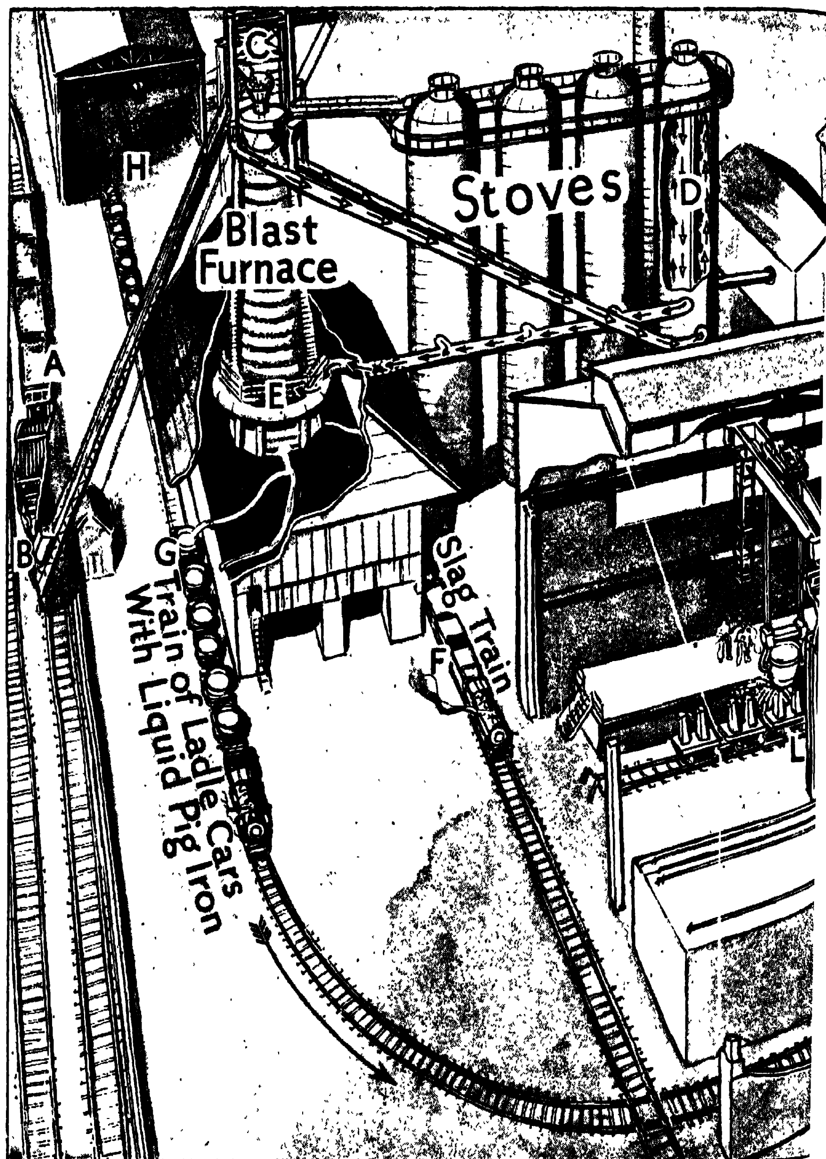
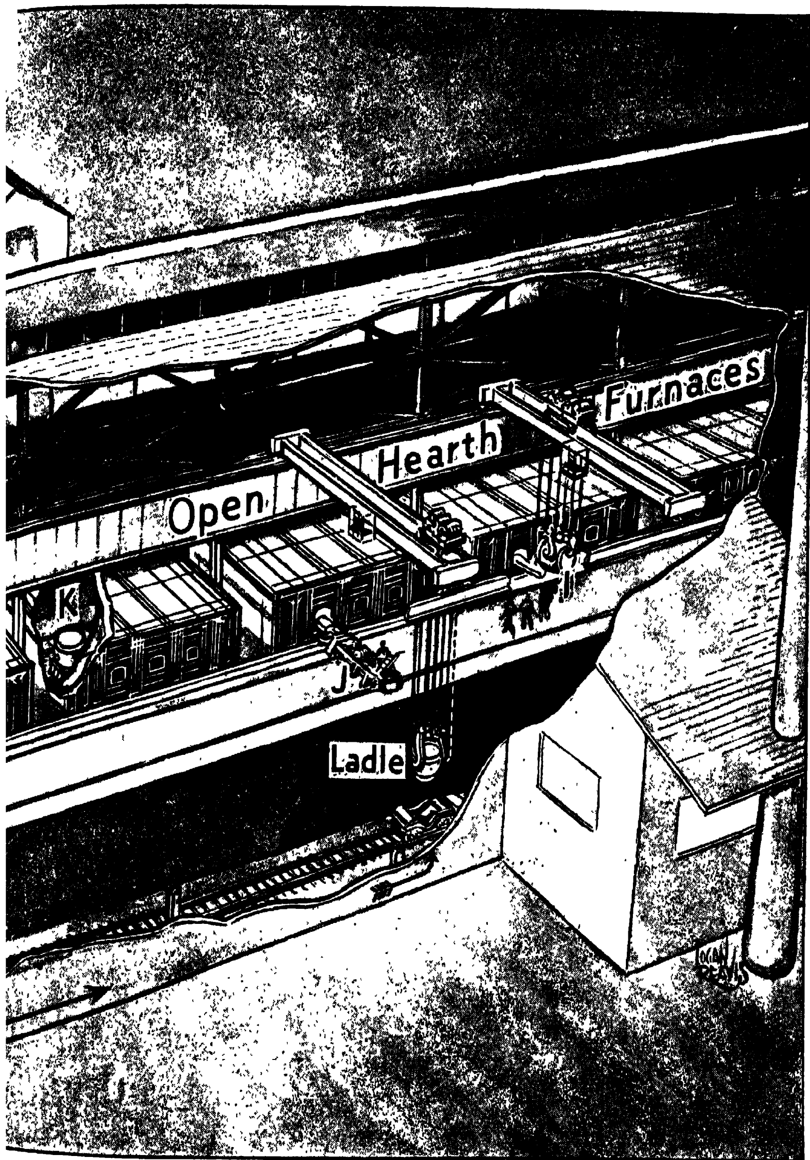


FIG. 72. This is a plan, or diagram, Mr. Thompson made to show you the steps in making pig iron and steel. If you look on it for



each of the letters as he mentions them in his story you will see what a long and complicated process steelmaking is

"Well, I don't know whether you can understand how hot it is just from knowing the temperature, but that fire is hotter than you can imagine. You know that water boils at 212° F. Well, at the top of the furnace the heat is about 400° F. At the middle of the furnace, which is about 50 feet from the ground, it is 900° F. and at the bottom it is about 2750° F."

"A temperature of 2750° F.! Thirteen times as high as boiling! How do you ever make such a hot fire, even by using coke?"

"To get such a hot fire, air is heated in the four stoves which you see in the diagram behind the blast furnace. One of the stoves (*D*) in the diagram is cut open to show you how the air moves inside. The hot air from the stoves is blown in at the bottom of the furnace (*E*) and, as I said, it raises the temperature as high as 2750° F.! The fire burns and burns all the time — 24 hours a day, never stopping.

"The iron melts and runs down to the bottom of the furnace. On top of the melted iron float the impurities called 'slag.' Every few hours the slag is drawn off near the bottom of the furnace and is carried out in a slag train (*F*)."

"Do you throw the slag away?"

"No, not nowadays. The ironmakers used to throw it away, but today not even the slag is wasted. For years our scientists and engineers experimented with it. They invented ways to prepare it and use it in making Portland cement. In our plants over the country we make millions of barrels of cement each year. In some



Ritchie

Fig. 73. Pig-iron ladles being filled at the blast furnace

places slag is crushed and sorted into different sizes to be used in place of gravel in making roads. It is also used under railroad rails in place of cinders or crushed stone. You can see, then, that slag from the iron furnace is very valuable. We save millions of dollars' worth each year.

"Now let us find out what happens to the melted iron. Every four or five hours this is drawn off from the bottom of the furnace and run into a train of ladle cars (at *G*)." Some of these cars are shown in figure 73.

"Sometimes when the pig iron is not going to be used at once, the liquid iron is cast in molds called pigs. This is done in the casting house (*H*).

"Often, however, the liquid iron is made directly into steel.

"In either case the iron, which is now called pig iron whether it is liquid or hardened into bars, must be treated in a certain way to make it into steel — that metal which is much stronger than iron.

Making Steel out of Pig Iron

"You will not remember much of what I tell you; but one fact is important to know. *Steel is an 'alloy'; that is, a mixture of metals and other elements;* and different kinds of steel are made by mixing these together in different amounts.

"Now, on our diagram, let us follow the pig iron as it goes on its way through the open-hearth furnace, in which it is turned into steel. The train of ladle cars



Ritchie

FIG. 74. Here you can see the liquid steel running into the giant ladle. The overflow at the right is slag

full of liquid iron stops in front of one of the open-hearth furnaces, and a huge crane lifts one of the ladles, swings it over, and pours the liquid iron into the open-hearth furnace (at *I*).

"In this furnace scrap steel, limestone, and some other materials are added to the pig iron. These are put into the furnace by a charging machine. You can see them going into one of the other furnaces (at *J*). The mixture is heated for eight or twelve hours. Then the contents are removed at the back of the open-hearth furnace (at *K*), the slag going into one ladle and the steel going into another ladle (figure 74).

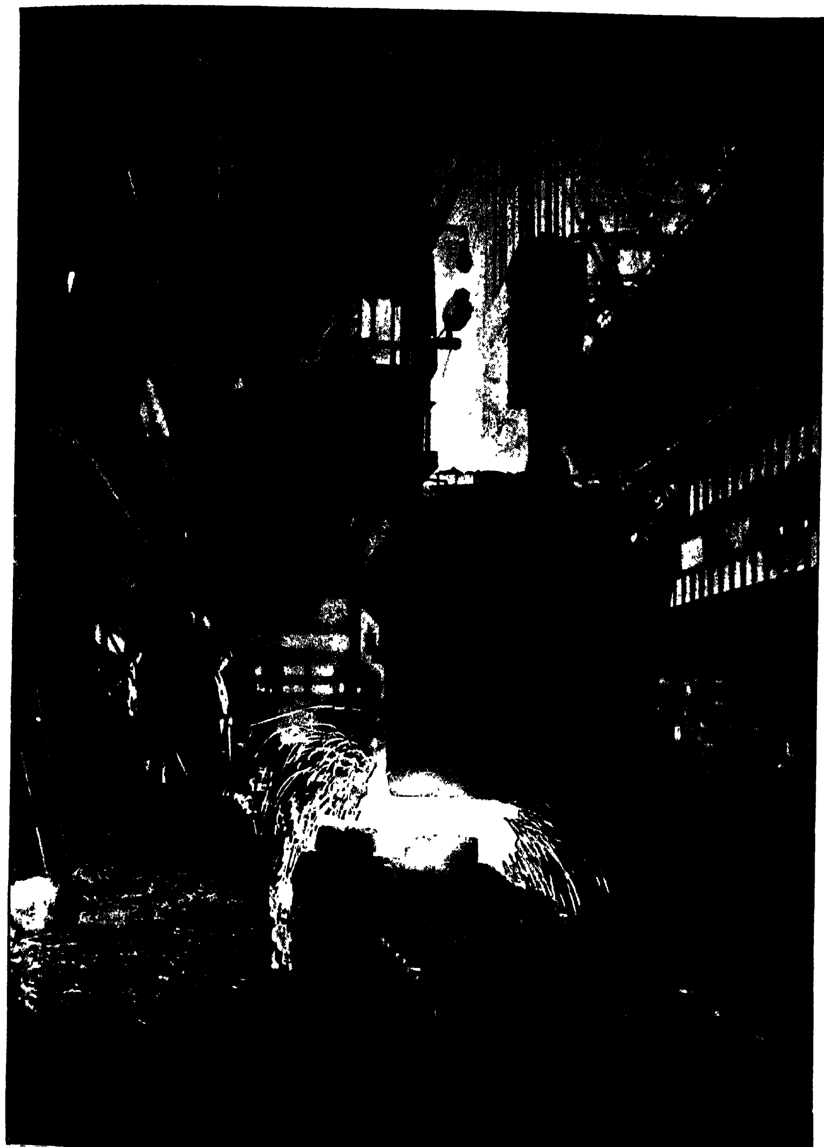
"In the diagram the liquid steel has been drawn off into the huge ladle (*K*). Next the ladle has been moved over by a giant crane. Then the liquid metal (which is now steel) is run into molds, from an opening in the bottom of the ladle, to make ingots (*L*)."

Figure 75 shows you a picture of a huge crane emptying liquid steel into ingot molds.

We look around us. Everything is of steel and concrete. We stand on a high balcony and look up at the roof, 100 feet from the floor. Around the room are steel cables holding enormous steel ladles, which move up and down on a track high in the air. "Traveling cranes," we think, as we watch them move along.

"But there are so few men at work!" we exclaim. "Things seem to be moving by themselves."

Yes, that is true; but high above the floor are several men on the crane platforms. They are guiding every part of the work with levers and buttons.



Bourke-White

Fig. 75. The man on the traveling platform guides this huge ladle over the line of molds to be filled with liquid steel

On one platform a man pulls a lever. Things begin to move. The lever has started the electric power in one of those huge cranes. It drops down and picks up a ladle holding 100 tons of hot metal. Then it moves down the track. On the platform the man moves another lever. Now the ladle stops. "A pretty big ladle!" we say, thinking of the little one that is used to put soup into our plates on the dinner table.

Another lever is moved by another man on the platform, and the ladle, hung by several pulleys and cables on the high track above, moves slowly down the room. It stops over some molds which look like huge steel boxes (figure 75). Another lever is moved, a hole is opened in the bottom, and a stream of hot liquid metal flows out into the mold. Soon the mold is full. The ladle moves on to another mold, fills it, moves on to another, and so on until all are filled. The pouring is done.

"That mass of hot metal in each mold is steel" Mr. Thompson went on. "It has just the right amount of carbon and manganese and other elements to give it the needed hardness, or toughness. It will harden and become an 'ingot.' An ingot is a huge block of hot steel (figure 76 shows one hanging from a crane) weighing from 1000 to 8000 pounds; that is, from half a ton to four tons."

"But, Mr. Thompson," exclaims one of the children, "isn't there another way of making steel out of pig iron? In one of our books, *The Building of America,* we read how a Kentucky kettle-maker named William

Kelly learned how to take the impurities out of pig iron by blowing air through it. Is that the way it is done today?"

"Yes, indeed. The way you've just seen is called the 'open-hearth' process. It was invented about 70 years ago. The other way is the Bessemer process. Nearly 80 years ago William Kelly in America, and a few years later Sir Henry Bessemer in England, discovered the air-blowing process, and today it is named for Henry Bessemer. I wish you could see this process. When the air is blown through, it's like a giant Fourth of July celebration! I'll tell you how it is done.[1]

"Imagine a huge room with a raised platform in one corner. On the platform stand several men moving levers. A little lower to the left is another platform, and alongside this is a third. On both these lower platforms men are pouring steel into ingot molds that are mounted on cars. Those are hauled away as they are filled. At the other end of the room one sees three enormous egg-shaped monsters hung on a level with the highest platform. A whistle shrieks. 'Number 3 is going to pour,' says the guide, and one of the monsters, looking like a huge egg with the top sliced off, tips over and pours into a ladle its load of steel. The hot metal glows like the sunset and shoots millions of sparks all down the length of the room.

"Quickly a man on the platform pushes one of the levers, and down turns the huge converter, while from

[1] For the facts in this story the authors are indebted to *The Story of Steel*, by Donald Wilhelm. Copyrighted by the United States Steel Corporation.

its glowing mouth tons of slag drop onto a car. The vessel turns. Out over the bridge beside it a man walks carefully, his eyes protected by colored glasses. He looks down at the red and white bottom that is to hold more of the hot metal. . . . If all is right, he merely gives a signal and makes his way back over the bridge, and a car is run out with a ladle full of iron from the mixer. This is poured into the converter, and air is sent through it. There is a mighty roar. Up toward the ceiling, against the metal roof, millions of sparks fly, their color changing as the carbon and silicon in the iron are burned. As the air rushes up through the hot metal it burns the impurities out.

"Those are the principal ways steel is made today. Each of them ends in the ingot. From the steel ingot are made railroad rails, parts of bridges, and a great many other large things we use today. Shall we go on and see how it is done?"

The Third Step: Making Things from Steel

An Example: Rolling a Steel Railroad Rail

We go over into another room that looks like a train shed at the railroad station. A man on a platform moves a lever, and a traveling crane (What would industry do without those great 'pickers-up'!) moves over to a line of freight cars in which steel ingots are piled. The long arm of the crane swings down. The steel fingers open and shut, like sugar tongs, on an ingot weighing 6000 pounds.

Another lever moves. Up swings the crane, the



Fig. 76. The crane is lifting a white-hot ingot of steel that weighs three tons

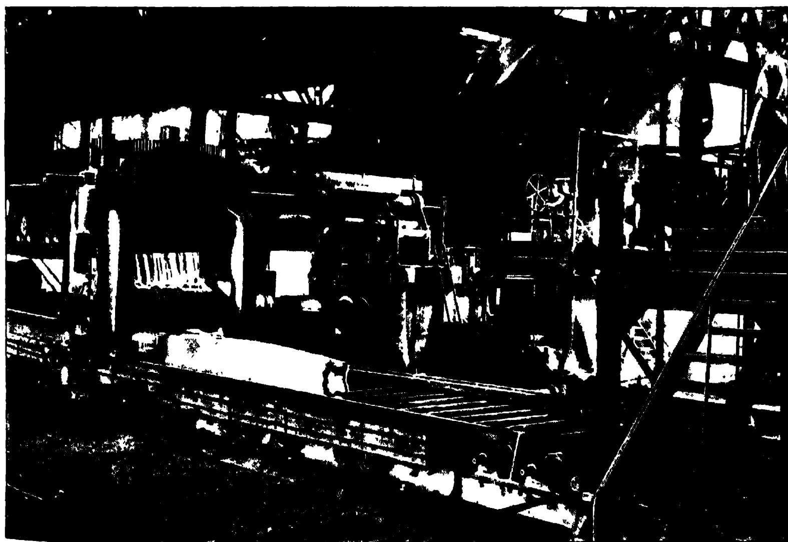


Fig. 77. Here the ingot of figure 76 is being rolled thinner and longer. Soon it will become a railroad rail

ingot hanging from its end. Then it moves to one side of the shed and places the ingot in a deep pit in which is blazing an intense fire of gas (figure 76). For two hours or more the ingot remains in the fire, getting hotter and hotter. An engineer stands by, measuring and controlling the heat. For one kind of steel he must give a certain amount — so many hundred degrees; for another kind a different amount of heat. Each special steel is worked over at just its special temperature.

When the ingots are of just the temperature to be rolled into railroad rails, a crane is moved over the pit. It reaches down and picks a red-hot ingot as easily as you would a pencil, swings it around, and lays it down in just the right spot on a huge steel "table." At the end of the table are steel rollers (figure 77).

"Like mother's wash wringer!" we say. Exactly, only many times as big and thousands of times as strong, and run by electric power instead of by your muscles!

The "rolling" of the rail begins.

"What!" we exclaim. "Rolling a three-ton ingot?"

"Yes, watch that man on the little platform high up there on the side wall (figure 77). He will move more levers, and the ingot will slide back and forth. Watch those rollers at the end of the great table."

Quick as a flash the ingot slides straight at the rollers; straight between them it forces its way. And now it comes out on the other side of the rolls, squeezed into a flattened bar.

More levers are moved on that wall platform. Powerful steel fingers turn the flattened ingot on its side. *Bang!* It is worked back through the rollers and slides down to its starting place. Now the ingot is broader and longer. "Just like rolling out dough into bread and cakes!" Yes, except that this "dough" is hot steel. Back and forth it goes through the rolling mill, hardly resting between flattening squeezes. Thinner and thinner it becomes, longer and longer, as the rolls are put closer together.

Next the ingot is sent on to another table, where giant whirling saws cut it as easily as you would a piece of cheese. From there each long flat bar is carried, still hot, of course, by more machine hands and arms to a roughing mill. Here is more rolling back and forth; but, each time through, the bar becomes shaped a little more like a railroad rail.

From table to table it goes, through one set of rolls after another, untouched by human hands. No muscles are at work except to move the levers here or there or to push a button. Mechanical slaves everywhere are doing man's work.

At last the long T-shaped bar is finished. It has traveled a good city block from where it was squeezed through those first flattening rolls. Now it is cut into three railroad rails.

And then what will happen? Oh, another crane will glide along, guided by a man, and pick up the rails after they are cooled and straightened and swing them into railroad cars. And then a locomotive will be

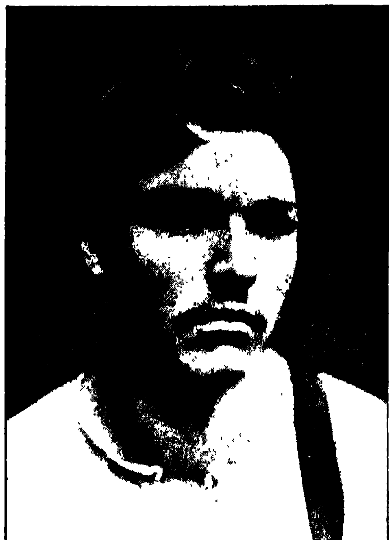
hitched on to pull the train of loaded cars out of the shed, and across the country they will go to Kansas, perhaps, or to California, Louisiana, or Maine. The cars will stop, and men will dump the new railroad rails beside a railroad track. Days later a gang of workmen will dig up the old rails and spike the new ones into place. And perhaps some day you will ride over them in a safe and comfortable train at 60 or more miles an hour. That is "the story of a railroad rail."

Thousands of Other Steel Things Are Made in Similar Ways

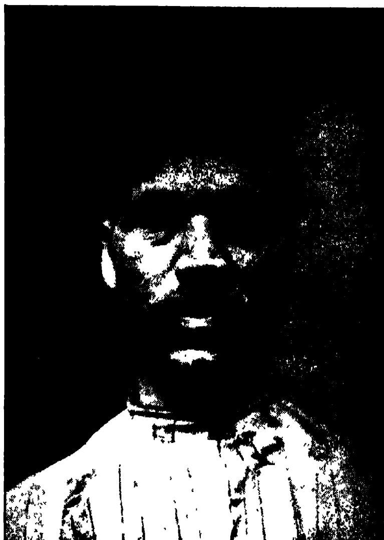
We have no space here to paint more word pictures of the ways in which countless other things are made from steel. We can only name a few examples and say that thousands like them are being made now in our steel mills each day.

Consider the many parts in a bridge, in a traveling crane, or in the frame that holds up the city skyscraper 50 stories high. Each part is made out of a red-hot steel ingot that is rolled or stamped by giant machines.

Little things, too, are made of steel almost without human hands and muscles. Do you remember how wire nails were made by our pioneer families? They hammered out long thin rods over a forge fire and cut them, one by one. Today nails are made by complicated machines which pull hot metal through holes in other steel machines and make it into steel wire. This wire is cut by other machines into tiny bits, the heads are formed on the pieces, and — lo and behold! — we have nails.



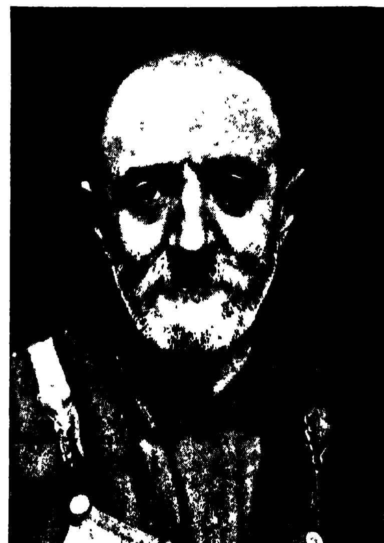
Slovak



Russian



German



Lewis W. Hine

English

Fig. 78. Men from many countries work in the steel mills

Iron and steel pipes also are made by machine. Hot furnaces melt the steel. Machines flatten the hot metal into sheets. Machines bend it into the needed shapes. Cranes lift and move the pieces.

So it is also with slabs and sheets and bars. All are made by machine. Axles are made from perfectly round rods. Automobile fenders are stamped out of sheet metal with the single blow of a great stamping machine. Gears, shafts, levers — every part has its parent machine, which makes it almost without the muscles of man.

Summing Up

We must complete our story of steel. Do you recall all the steps in the story? It began with digging iron ore out of the Mesabi hills of Minnesota. It took us by steamer to the steel mills of our country. It sketched the way coal is mined and coke is made. Finally it showed the work of real giants of industry: smelting iron ore in the blast furnace, changing raw iron into steel by the open-hearth way and the Bessemer way, and making things out of steel.

Now all these different kinds of work may be carried on by a single great company. It is one of the most unusual businesses in America. If you thought that the dairy company was a big thing, you will be astonished at the variety of things this steel company does. You need not try to remember all of them. Here are just a few of its many kinds of work:

It owns enormous iron-ore fields in Minnesota and other places and mines its own ore.

It owns and operates a fleet of steamships on the Great Lakes.

It owns and runs railroads.

It owns giant coal fields, mines its own coal, and makes it into coke in huge plants.

It owns and mines its own limestone fields and prepares its limestone for the steel furnaces.

It owns and runs many steel plants, making different kinds of steel.

Out of the steel it manufactures bridges, railroad rails, pipes, wire, sheet metal, tin plate, and scores of other things.

With its vast wealth it can employ scientists to make new experiments, inventors to think up better ways of doing things, engineers to arrange factories and mills in the most efficient way, and hundreds of thousands of skilled workmen to run the machines.

Today we call such large companies "corporations." Later you will learn more exactly what a corporation is. For the present, however, when you think of the wonders of iron-mining and coal-mining, of coke-making and steel manufacturing, remember that all these different kinds of work are carried on by one great company.

Books You Would Like To Read

CHASE, ANNE E., and CLOW, E. Stories of Industry, Vol. I. Educational Publishing Company, Boston. Stories about coal and mining. Oil, metals, work in brass and bronze, bits of King Iron's history, and a visit to a glassworks.

DANA, E. S. Minerals, and How to Study Them. John Wiley & Sons, Inc., New York. A book about minerals for beginners.

FRASER, CHELSEA. Secrets of the Earth. Thomas Y. Crowell Company, New York. Mines and mining.

MARTIN, EDWARD A. The Story of a Piece of Coal. D. Appleton-Century Company, Inc., New York. What coal is, whence it comes, and whither it goes.

ROCHELEAU, WILLIAM F. Great American Industries: Minerals. A. Flanagan Company, Chicago. The story of coal, copper and zinc, gold and silver, granite, iron, marble, natural gas, petroleum, slate.

TAPPAN, EVA M. Diggers in the Earth. Houghton Mifflin Company, Boston. In a coal mine; down in the quarries; iron, the everyday metal.

WILHELM, D. The Story of Iron and Steel. Harper & Brothers, New York.

WILLIAMS, A. How It Is Made. Thomas Nelson & Sons, London. How various machines and many articles in common use are manufactured from the raw materials.

WILLIAMS, ARCHIBALD. The Romance of Modern Mining (revised by N. J. Davidson). Seeley Service and Company, Ltd., London. Interesting descriptions of the methods of mining for minerals in all parts of the world.

PART V

Man the Power-Maker

DID you notice that in the stories you read of how people do their work, one word, *power*, appeared again and again? You saw that on large farms *power* was the important thing. In grinding flour, in preparing foods, in spinning yarn, and in weaving cloth, the engineers had invented machines which provided huge amounts of *power*. In digging iron ore by steam shovels, in mining coal, in transporting these things to the steel mills, in mixing and making them all into steel, the biggest need was *power* — *giant power*.

Power Is Needed in Every Kind of Movement

Let us think for a moment of the kinds of movements that we, as muscle workers, make.

1. *Lifting Things*

When we dig we lift things.
When we load or unload wagons we lift things.
When we change tires we lift things.
When we build we lift things.

Each day, in hundreds of ways, people lift things.

2. *Pulling Things*

Children pull wagons and other toys in their play.

In building, workmen pull up lumber and steel beams, bags of cement, and other things.

A man rowing a boat pulls the water with his oars.

A swimmer using the crawling stroke pulls the water.

In every kind of transportation things are pulled.

All day long, in many ways, we pull things.

3. *Pushing Things*

Pushing a lawn mower.

Pushing a wheelbarrow.

Pushing the water in swimming.

In skating we push our bodies along over the smooth ice.

In many, many kinds of work or play people push things.

There are many other kinds of movement that people use in doing their work. Can you add more to this list?

The important thing to remember is that in every movement *power* is needed. We cannot lift things without power. We cannot pull things without power. We cannot push things without power. Power is necessary to do any kind of work.

Giant Power All around Us Today

All around us today are many examples of man's use of power. We see a locomotive pulling a long train of freight cars over a mountain railroad. Such power! What makes it?

A giant shovel is digging up an old concrete road through the main street of our city. With one great bite the thing scoops up as much as a hundred workmen can dig with their hand shovels. What makes the power?

In a skyscraper an elevator loaded with ten people rises swiftly fifty stories up. What makes the power?

The *Queen Mary* sails from Europe to America in four days with four thousand people on board. What makes the power?

A man tramps wearily along a road carrying a load on his back. Another man drives a huge truck down the same road fifty miles an hour. What makes the power?

We see, then, that the story of man at work is partly the story of how people learned to make power. You already know part of that story. We must now study it more thoroughly to understand how men throughout the ages learned to make better and better power aids.

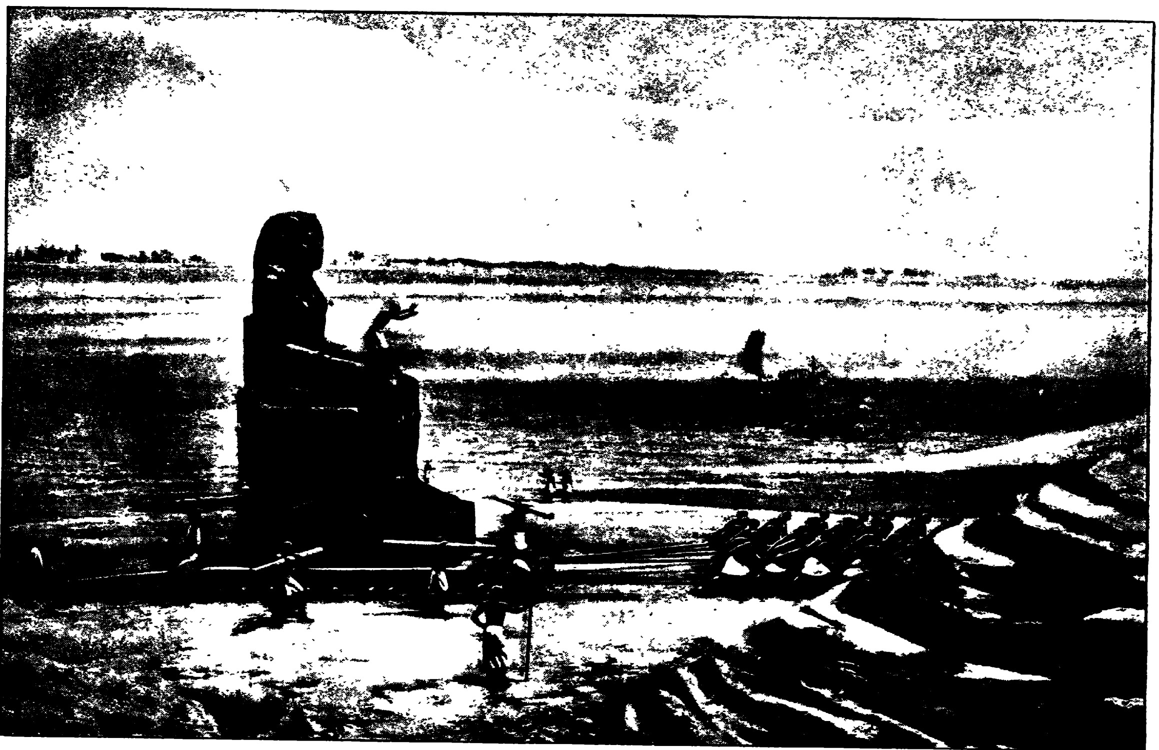


Fig. 79. Transportation in ancient Egypt. What power aids did the people have then?

CHAPTER VIII

Man's Simple Power Aids

LET US begin with the story of Bob and the other children moving Miss Harrison's desk.

The day after the children gave the play Miss Harrison called the group together at the big round reading table, where a committee of the children had arranged some open books. Behind them, on the blackboard, were some drawings.

Bob Davis was the chairman. He began:

"Yesterday we learned some very important things about doing work, but there were some things that we did not understand. Nancy's uncle, Mr. Charles Weston, is an engineer, so Miss Harrison asked him to come and talk to us. The committee has explained our problem to him, and he will help us.

"First, the committee will tell what we asked Mr. Weston. Will you begin, Nancy?"

Power Aids: Things That Increase Our Power

"Yesterday, Uncle Charles, we had a piece of work to do. That was to lift the desk and carry it to the stage. To do it we needed 'power.' The only power we had was in our muscles, and the muscles in our backs and arms and legs could not make enough power."

"So we had to get things to help us to increase our power," interrupted Tom, who could never wait when he had an idea.

"That's it," said Mr. Weston. "You used several different *tools*. The engineers call them 'power aids.' Anything that helps people to increase their power is a power aid."

"That's easy," put in Mary. "Aid means help; so we can remember that these power aids help our power."

"Yes," went on Nancy's uncle. "I have made some drawings on the board to show how the tools you used did that."

1. The Lever

"The first tool you used was the iron bar, which is called a 'lever' (see figures 1 and 80). In the drawing of figure 1 notice why the lever helped you to lift the desk. The bar rested over the block of wood, which is called a 'fulcrum.' Now the iron lever was long and heavy. It increased the power of your arms because it increased the distance through which they worked. When you began to push down, the lever helped you to balance the weight of the desk. Then when you pushed down hard enough, your weight and the lever's weight balanced the desk and raised it from the floor so that you could put a roller under it."

"If we had used a larger block and a longer and heavier lever, would it have been easier to raise the desk?"

"Yes; but of course the bar and the block must



FIG. 80. Can you see how this Egyptian has increased his power by the use of the lever?

not be too long or too heavy, or you would not be able to handle them easily. I have brought some pictures to show you other examples of the lever."

All the children were interested. They began to see how the lever helped man to increase his power. Bob went on:

"After we raised the desk from the floor, we still had to move it along the floor. What was the next power aid, Mr. Weston?"

2. The Roller, or Wheel: Reducing Friction by Rolling Things

"The next tool you used was the roller. The broomsticks were really rollers, or wheels. Thousands of years ago people learned that it was easier to roll things than it was to carry them or to drag them. Which is easier, to roll a log or to carry it?"

"To roll it, of course," answered all the children.

"You say 'of course,'" explained Nancy's uncle; "but it took men thousands of years — maybe hundreds of thousands — to discover that it is easier to pull a heavy load if it is on round logs than if it is on just a broad, flat drag (figures 1, 79, and 81).

"But why is it easier, Mr. Weston?" asked someone.

"Well, you can see that the bottom of the desk touches the floor all over, so that the desk sticks hard to the floor. If all of us pushed together, we could probably push the desk along the floor; but it would be hard to do it because so much of the two surfaces touch each other. The desk touches the roller only on a thin line, and the roller touches the floor only on a thin line. We say there is less 'friction' between the desk and the floor when the rollers are between them."

3. Working on Inclined Planes instead of on Vertical Ones

"Now about lifting the desk onto the stage. You were not able to lift it straight up, that is, vertically. But you could roll it up the slanting planks. Why? Because the boards were long enough to make an easy,

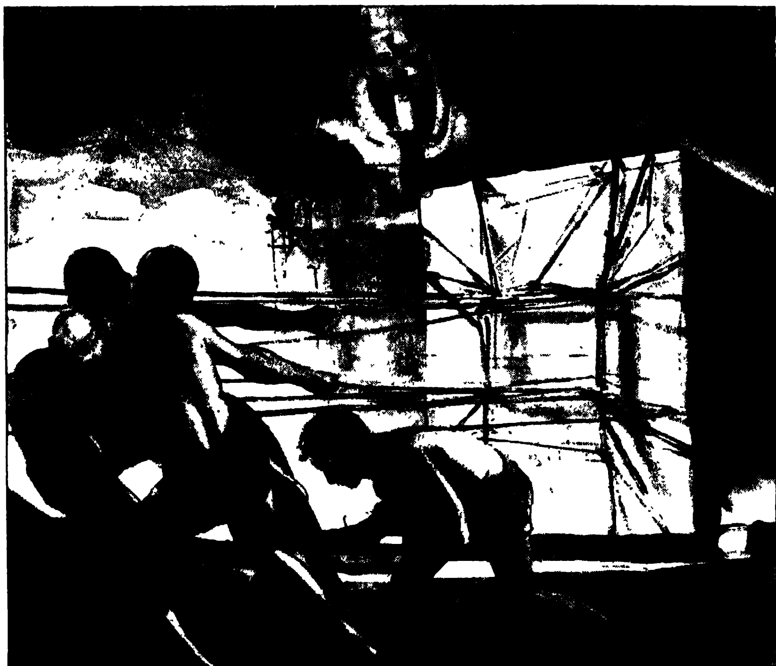


Fig. 81. Thousands of years ago people learned that it was easier to roll things than it was to carry or push them

gradual slope. We call such a slope an 'inclined plane.' It requires much less power to roll the desk up on the incline, or slant, than to lift it vertically."

"Oh, yes," exclaimed Gladys; "it's like walking up a long, gradual hill instead of climbing up the side of a rocky cliff!"

"Right! said Mr. Weston. "Engineers build railroad tracks on very gradual slopes for the same reason. Locomotives cannot pull trains up steep slopes. So in

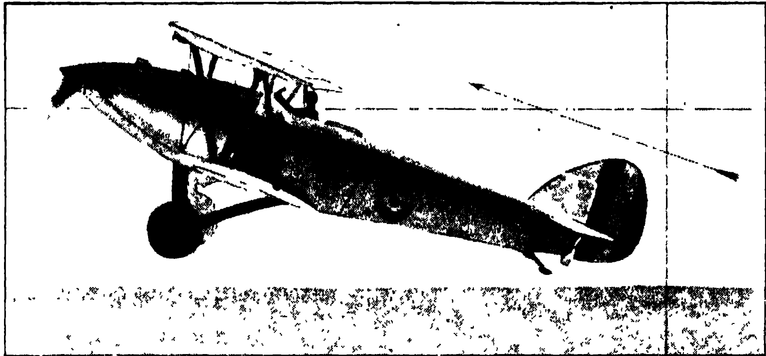


FIG. 82. The airplane rises on an inclined plane

order that trains can cross mountains, tracks are built along the sides through the valleys. Gradually they rise higher and higher, until finally they cross over through the bottom of some pass."

"So both a road and a railroad track work on an inclined plane!" said Gladys.

"Yes, and so does an airplane when it rises in the air (figure 82). There are many inclined planes all around us."

4. All Simple Tools Can Be Called Power Aids

"Are there still more power aids besides the lever and the wheel and the inclined plane?" asked Mary.

"Oh, yes; many. Every tool we use is a power aid. Hammers and axes, sickles and scythes, are power aids. They increase the power of our arms. A screw driver is a power aid. It increases the power of our fingers. A hand pump is a power aid. A shovel is a power aid. In fact, any tool is really a power aid.



FIG. 83. The windlass draws this heavy bucket from the well. Can you tell how this is done?



FIG. 84. The jack which is raising the building is a screw. Why does a screw work like an inclined plane?

"But there are some other special kinds of power aids. I asked Bob to bring along some examples of them."

"Yes," said Bob; "here they are."

Bob brought out a bag containing some screws and a jack (figure 84).

"Mr. Weston, will you tell us how they work?" asked Nancy.

5. The Screw: A Spiral Inclined Plane

"The screw is one of the most important power aids, since it is used in many, many kinds of work. Any automobile jack is really a screw. Let us take this one to pieces and see how it works.

"Five or six men would be required to lift the corner of an automobile with just their own muscles for power; but with a jack any one of you children could raise it alone, so much greater power does the screw give to us (figure 84)."

6. The Wheel and Axle

"Another power aid is one known as the wheel and axle. This helps us to lift things and move things. One of the simplest kinds is the windlass, which is used in raising water in a well. Let us look at the picture (figure 83) to see how the windlass works. Notice that there is a roller fastened to a wheel, or crank. The rope is fastened to the roller, and as you turn the wheel, or crank, the rope winds up the bucket of water. With this kind of power aid even a child can draw a heavy bucket of water up a well."

7. The Wedge: Making Friction Do Our Work

"Now here is the simplest power aid of all, and yet it is one of the most useful! That is the wedge. Wedges are all around you. The little V-shaped piece of wood that holds the door open is a wedge.

"An ax is a wedge (figure 85). If you place a log up on end, you can split it with an ax. At first the ax sticks in the log. If you pound the log harder and harder on the chopping block, the ax drives, or 'wedges,' the two sides farther from each other. Suddenly they fly apart. The ax has pried them apart. There are many other wedges which I am sure you have seen and used.



FIG. 85. How does the boy's ax work? Of what power aid is it an example?



FIG. 86. Can you explain the power aid that Gladys used to lift the heavy suitcase?

"In the use of wedges friction is a help to us. The woodcutter's ax sticks in the log because of friction. A nail is a wedge. It holds two boards together because of friction. Look at the wedge-shaped end of a pin. Push the pin into two pieces of paper just far enough to reach the end of the wedge. The pin holds the two pieces of paper together because of friction. Do you see how friction can sometimes be of use to us? how it increases our power?"

8. The Pulley

"Here is one more power aid that helps us to lift things," said Nancy's uncle as he held up a pulley (each wheel in figure 86).

"Two very simple ideas are used in the pulley. Come outdoors to that tree and I'll prove it to you."

The children followed Mr. Weston out to the playground. There he filled a heavy suitcase with bricks and tied a long rope to it.

"Now, Tom," he said, "see if you can lift the suitcase."

Tom tugged and tugged, but he could not raise it from the ground. Then Mr. Weston threw the rope over the limb of a tree.

"Now see if you can pull the suitcase up!"

Tom pulled hard. Slowly the suitcase rose from the ground. All the children were surprised.

"How is it that Tom could lift that heavy weight with the rope over the tree when he could not lift it straight up?" was their question.

"Because it is easier to pull down than it is to lift up. That is partly because Tom's own weight is pulling down too."

"Then," said Tom, "even throwing a rope over the branch of a tree is a power aid, isn't it?"

"Yes; but this pulley is a still better one."

Mr. Weston tied a pulley to the branch. Then he tied one end of the rope that ran through the pulley to the suitcase.

"Now, pull it up, Tom."

Tom pulled and easily lifted the suitcase of bricks high in the air. Gladys pulled, and she too could lift the heavy weight.

"But why is it so much easier now than it was when the rope was over the branch?" she asked.

"Because there is almost no friction of the rope on the pulley. The pulley is really a turning wheel. It turns as the rope moves. Without the pulley the rope rubs hard on the branch, and there is great friction between the two; so it is harder to pull."

"Then friction doesn't always help, does it, Mr. Weston?" put in Ralph.

"No. In this case friction prevented us from doing work, so we used the pulley. In the wedge friction helped us to do work."

"There are many ways that pulleys can be used," he went on. "I could use more than one pulley and arrange them in such a way that you could easily lift a much heavier load."

Mr. Weston then tied another pulley on the suitcase. He ran the rope through both pulleys (see figure 86). Gladys pulled again on the rope. She could now lift the heavy weight even more easily.

"My, the pulley is a fine power aid!" exclaimed Nancy, as the children returned to their room.

Books You Would Like To Read

LANSING, M. F. Man's Long Climb. Little, Brown & Company, Boston. An industrial reader giving the history of plowing, the domestication of animals, the fashioning of clay dishes, the principle of the lever, and the story of the wheel.

WILLIAMS-ELLIS, MRS. A. Men Who Found Out: Stories of Recent Scientific Discoverers. Coward-McCann, Inc., New York. Stories of scientists, telling what led the men toward their discoveries.

CHAPTER IX

Muscle Power among Nature Peoples

Man's Power a Million Years Ago

OUR STORY begins when the first true men lived on the earth. That was, as we learned in *The First Book of the Earth,* perhaps two million years ago. Even then people had to have food, and that meant that they had to do work. As you know, they did not raise their food: they hunted it. They used the limbs of trees as clubs to kill the wild animals. They rubbed sticks on stones and speared fish with the sharpened points. With sticks too they dug holes in the ground and trapped the animals. Sometimes they stood on high cliffs and pushed huge rocks down upon them as they passed below. All this was hard work, very hard work.

Where did these first true men get the power to do their work? They had no guns or even bows and arrows. They had no plows or other tools, and no animals to work for them. They had no windmills to raise water from deep wells. And, of course, there were no steamboats or railroads, no sailing boats or even canoes. All their power came from their own muscles.

Power Aids among Neanderthal Men

Now think of a time somewhat nearer our own — about 100,000 years ago. Do you remember the story



A. M. N. H.

FIG. 87. What power aids did these early men have?



FIG. 88. The lake dwellers used stone axes to build their villages

that was told in *The First Book of the Earth* of the family of Neanderthal people who lived at "the squatting place"? When the father and boys went hunting, they took spears with points of sharpened stone. For cutting down trees and killing big animals they had axes. To shape the limbs of trees into ax handles, they had knives and scrapers. But the knives and scrapers and axheads were made of thick, blunt pieces of stone. These were their only tools.

What kinds of power aids had human beings invented during the million or more years that had passed? They knew how to sharpen stones for cutting their axes, knives, and scrapers. They probably knew how to use long sticks as levers to help them to lift things. But whether they had learned how to move things by rolling them on logs instead of carrying them, we do not know. Even if they did know how to use rollers, we can feel fairly sure that they had not invented the wheel, which works on the same idea. And there is no sign that these early men knew the use of the pulley and the axle.

Were these, then, the only gains in power even after a million years? Our scientists think they were. Families lived and died. Sons learned from their fathers the simple ways of doing things and passed them on to their own sons. Centuries passed in that way. In hundreds of thousands of years, even in a million years, people continued to depend upon their muscles for power. The gains seem little enough for all that time, do they not?

Power among Nature Peoples

Many more thousands of years passed. Families and tribes of nature peoples had moved about over the earth. Some of these stayed in Asia; others moved into Europe. Some crossed over into Africa, and it is thought that others traveled to North and South America. Still others found a way to reach Australia and lands that are now islands in the oceans.

We cannot be sure, of course, of how these nature peoples of 10,000, 15,000, perhaps 25,000 years ago, lived at that time, but scientists think that their ways were somewhat like those of the nature peoples who are on the earth today. Let us imagine that we are looking in on some of these tribes. How do they make power? What aids do they have?

The Bushmen of the Desert

There, on the hot sands of the South-African desert, is a hut of some little Bushmen. The broken bones of a deer lie scattered in piles before the hut. Yesterday the men chased a deer for 20 miles and finally killed it with poisoned arrows shot from their bows. Then they carried the deer on their backs to their wives and children. What a feast they had! They had eaten until their stomachs bulged with the food. Now the whole family is sleeping inside the hut.

We look around. What do these people use to help them to do their work? Are there plows to cultivate the ground and oxen to pull them? How do they get

their water? By pipes from the reservoir outside the town? By windmills from a well beside their hut?

How did they build their hut? By a great steam-driven derrick which lifted the steel and stone up story after story?

No doubt you are laughing at our suggestions of their ways of working, for you know from the stories of *Nature Peoples* that these Bushmen have nothing of the kind. They do not raise food; they hunt deer and other animals with bows and arrows. They gather birds' eggs and berries and catch fish and lizards and even snakes to eat. They are food-gatherers.

Nor do these Bushmen dig wells for water. When the rains come during certain months, they gather the water carefully in ostrich-egg shells and bury it deep in the ground.

As for building houses and transporting things! Their shelter is a hut or windbreak of sticks and bushes, and they are their own "beasts of burden." They do have dogs in large numbers as companions, but it never occurs to a Bushman that a dog could be trained to carry things for him.

What, then, do they use for power? Have they any power aids? One little aid they have learned to make: the bow. With this a Bushman can shoot an arrow over a distance of several hundred feet. The bows are very skillfully made too. But even to shoot their bows, and to do any other work which is necessary, they depend on the muscles of their backs and arms and legs and hands. Nature peoples they are, indeed!

The Fang of West Africa

Let us look in on one other tribe of Africans — the Fang. In *Communities of Men* you read that they live in their villages in the forests along the Ogowe River. Just now the people are away in the gardens a mile from the village. We can see the men and older boys chopping down the trees on the hillside with their axes and their long, swordlike knives which we call machetes. All day long their dark-skinned backs and arms sway and swing to the hard work.

After they have cleared a large space, they set fire to the trees and bushes. For a day or more the hillside burns. Then come the women, who plant bananas and manioc roots and the seeds of gourds. Day after day they stoop over, making their gardens in the ashes.

Meanwhile other Fang people are fishing in boats on the river. Long lines of men swing their oars together. Back and forth move their bodies as they do the work of pulling the boat through the water.

"More muscle power," we think, as we see that the Fang plant and build, as well as row their boats, with little to help them but their backs and arms and legs.

These tribes show that there are still people on the earth today who depend almost entirely on their own power. On every continent and on many islands they can be found. In Africa alone there are nearly 1000 tribes of such nature peoples. Many of them live like the Fang. If they go to market, they carry things on



Ewing Galloway

FIG. 89. In Siam a woman raises water to irrigate a rice field by treading on a crude paddle wheel

their heads or their backs. Some of them use oxen or water buffaloes to plow and cultivate the soil; but most of them lift and push and pull, pound and grind, hammer and cut, almost entirely with their own muscles.

What, Then, Did These Early Nature Peoples Know about Power?

Perhaps you are thinking, "The people who lived many thousands of years ago did not know much about making power!" That is true; for they lacked most of the simplest power aids that the children of Miss Harrison's class learned to use. They did not know how to use wheels and axles and pulleys and so did not use carts or wagons or other vehicles.

They did not know how to use windmills or water wheels to pump water and do other kinds of work.

They did not use horses or oxen, donkeys, elephants, camels, or other animals to transport things, to pump water, to grind corn, or to do other kinds of work.

And, of course, they did not have engines, and they had never dreamed of locomotives and autos, airplanes and trains. "Dig a hole as large as a house at one scoop of a shovel? How absurd!" their wise men would have said.

All the things that you can see about you in any town or city today were beyond the wildest dreams of any of these people of early times. Not for several thousand years more would men learn how to make such astonishing power aids. Many simpler things would have to be invented and a very long time would have to pass before these things would come.

But there were people on the earth even 8000 or 10,000 years ago who did invent some simple power aids. In the next chapter we shall see who they were.



FIG. 90. An artist imagines how the Egyptians built the Great Pyramid.[1] What kinds of power aids did they use?

CHAPTER X

Man's Long Dependence on Natural Power

AS THOUSANDS and thousands of years passed, something was happening to the minds of men! They began to think better. They got ideas such as they had never had before. Inventors appeared among them who suggested better ways of lifting, pulling, pushing. Of course these changes came very slowly; but, little by little, men did succeed in inventing all the simple power aids that we read about in Chapter VIII.

When these inventions took place, we do not know exactly. Our scientists agree generally that it must have been at least 8000 or 10,000 years ago. Where they happened first, which people were the first to use them, we do not know. Some scientists think that several different peoples, living in continents far from one another, invented them separately. They say that the Chinese and the East Indians in Asia, the Egyptians in Africa, and the Chimus of South America were using these things at about the same time.

Other scientists think that the people who lived in Egypt along the river Nile were the first to make those power aids. They say that traders among the Egyptians traveled by land and sea to other lands and that they taught the peoples there how to work in better ways.

[1] From Pahlow, *Man's Great Adventure.*

How the Egyptians Built the Pyramids

Whichever way it happened, we are sure that in the Egypt of 5000 years ago several *mechanical* ways of increasing human power were used. We know that is true because men who have studied its history have proved that the pyramids, those huge tombs of the Egyptian kings, were built as long ago as that. One of these – the Great Pyramid of King Cheops – was erected about 2900 B.C. What a giant building that is! Today it stands on the desert as it did nearly 5000 years ago. It is 480 feet high, with a base larger than a city square, and 2,300,000 stone blocks were used to build it. Each of these blocks weighed about 5000 pounds, and the total weight of the pyramid is over 5,000,000 tons. It took 100,000 workmen twenty years to build it.

We know that even at that time the Egyptians knew how to cut stones with wedges and metal chisels. A history book which was written nearly 2000 years later tells us that the stones were floated on flatboats from the quarry, some miles away, to the place where the Great Pyramid was to be built. They were then pushed and pulled up an enormous inclined plane of polished stone 60 feet wide and three quarters of a mile long! To build this incline and the base of the pyramid required ten years. So we can be sure that the Egyptians knew the wedge, the lever, the roller, and the inclined plane.

Did they also know how to increase their power by

the wheel and axle, the pulley, and the screw? There is much reason to believe that they did. We know that they swung some of those huge stones into place from step to step (a single step is six feet high) by means of baskets hung by ropes from swinging wooden beams. These were really a kind of derrick, or crane. A little later pulleys were used to reduce the friction of moving ropes. Some of our scientists think that the Egyptians knew how to wind up heavy loads by means of the screw, as we do with our simple automobile jack.

The Egyptians Knew the Advantage of "Teamwork"

The artist's drawings of figures 79 and 90 suggest another thing that the Egyptians had learned about building. That was teamwork. They had found out that many men pulling or lifting at the same moment could move a heavy load that one man alone could not budge. So they arranged their workmen in groups, or "gangs." Scores and more of slave laborers worked together in a gang managed by a leader. Each leader (we could call them "engineers") used his mind in planning how his own men would work together. Over him there were other leaders, planning how their part of the work and other parts would fit together. Can you see what a group of intelligent engineers these leaders of Egyptian building must have been?

So it seems clear that as long as 5000 years ago (and some scientists think much longer) the people who lived around the Mediterranean Sea knew how to use

simple power aids to help them in their work. Far ahead, indeed, were their ways of working over the simple ways of the nature peoples who had gone before them.

The Peoples of 5000 Years Ago Had Tamed Animals To Work for Them

These ancient peoples had also thought up another way to help them to do their work. To the power of their own muscles they had added the power of the muscles of animals. In Egypt and other countries around the Mediterranean Sea they had trained the ox to pull their plows and carts. In India and in China the bullock and the water buffalo (figure 91) were working in the rice fields. In India the powerful muscles of the elephant (figure 91) were also turned to good use in carrying and lifting heavy loads. In Tibet the people had tamed the yak (figure 91).

For no one knows how long horses had roamed untamed over the steppes of Siberia (figure 92).

For man to learn how to tame horses to wear bridles and saddles and to follow directions must have taken a long, long time. But there came a day when people were riding on horses and using them to pull loads. Exactly who did this first and when it took place we do not know, but certainly 4000 years ago horses were carrying the wandering peoples of Asia into Europe. By 1700 B.C. the Egyptians had horses which they got from the people who lived on the eastern shore of the Mediterranean Sea. Later the Greeks and the Romans

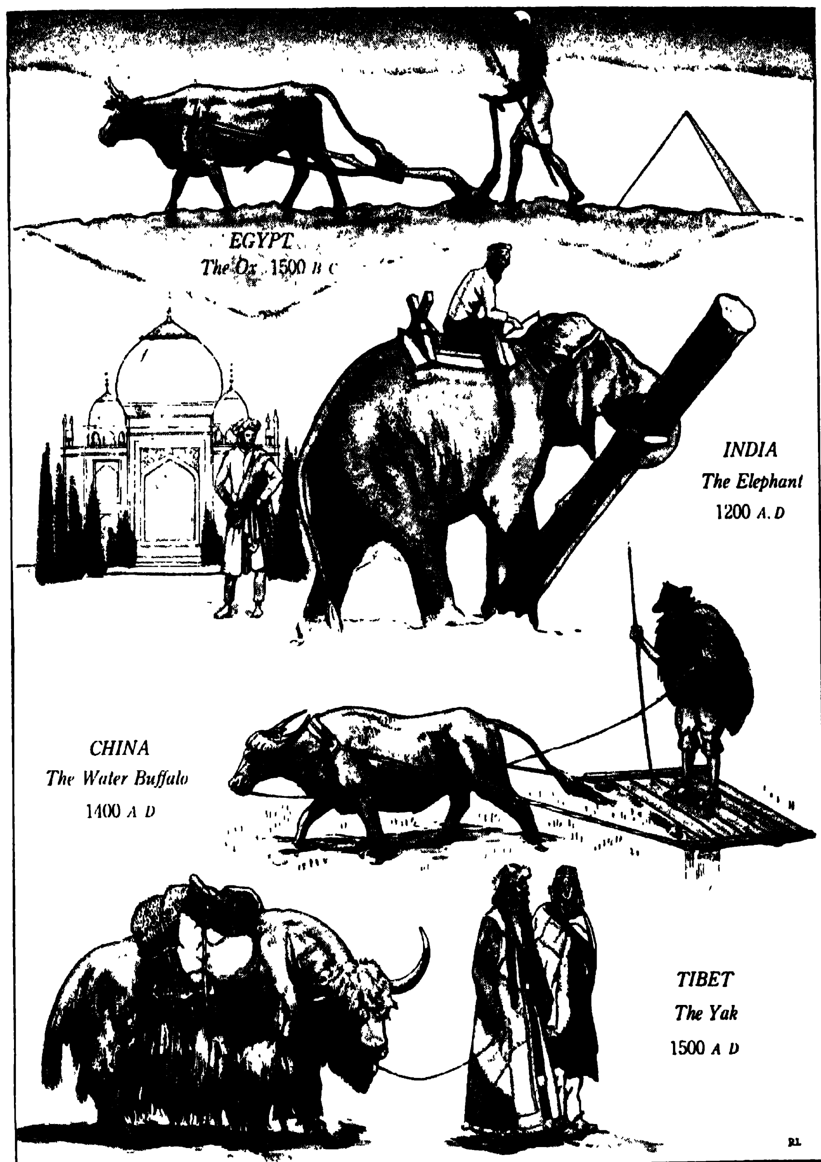


Fig. 91. Through the centuries man has used many different animals to help him in his work



New York Zoological Gardens

FIG. 92. Small horses like these ran wild in Asia for thousands of years

used them for riding and for pulling loads, and, of course, the Europeans nearer to our time did so. Not until very recent times, however, were horses used for plowing and other farm work. For this the Europeans, as well as the Asians, continued to use one or another kind of ox.

Strangely enough, there were no horses in North and South America before the Europeans came. As you learned in *The Building of America,* it was the Spanish explorer Cortes and his men who first brought tamed horses to America. Some of these horses got away from the Spaniards and became wild again. They roamed the plains of the two Americas. As time went on, there were more of them, and the Indians of the plains learned how to catch them and tame them. By

the time the English began to settle in this continent (after 1600) some Indian tribes were using horses.

The dog is another animal that man learned to use for his work. For many thousands of years dogs were the companions of men. In some of the caves in which the bones of early people have been found, the skeletons of dogs lie beside them. Whether or not these cave dwellers trained their dogs to carry and pull loads we do not know.

The globe maps on pages 164 and 165 show that all over the earth many other interesting and different animals have been trained to use their muscles for power to do man's work.

The Work Animals Fitted the "Geography" of Their Region

It is interesting to remember that, in general, the animals which people tamed and trained in each region were the special ones which had learned to live there. The yak could live in Tibet, the "roof of the world," during the cold winters because of his coat of heavy hair. The water buffalo was especially fitted to live in tropical lands. Goats could live in mountain regions where food was scarce and the air was cold. Their feet were formed in such a way that they could move on the slopes without slipping and falling. So people of the mountain regions on several continents began to use goats to carry loads for them.

As you know, the chief work animal of the desert is the camel. During the millions of years in which the



Map 2. These are some of the animals that the peoples in the Americas trained to help them in their work



MAP 3. What are some of the animals that did man's work in the Eastern hemisphere?

many, many kinds of animals were appearing, the camel (figure 94) became "the ship of the desert." Everything about him seems to have grown with the idea of living in this kind of land. Notice his head, which rests on a long neck; his flat, narrow nostrils; his legs, with their heavy foot pads and knee pads. Those broad foot pads help him from sinking into the sand. When the camel kneels down so that his master can mount him, or when he "folds up" to rest, he needs those thick knee pads. That heavy mat of hair protects him from the terrible heat of summer and the piercing cold of winter. The long, flat nostrils keep the desert sand out of his lungs. And that hump (one, if Arabian, and two if Bactrian of central Asia) is a kind of storehouse of fat which enables the camel to go for several days without food. Most important of all, however, is his stomach, which has many little pouches, or bags, that hold water. These permit him to go for four or five days without drinking.

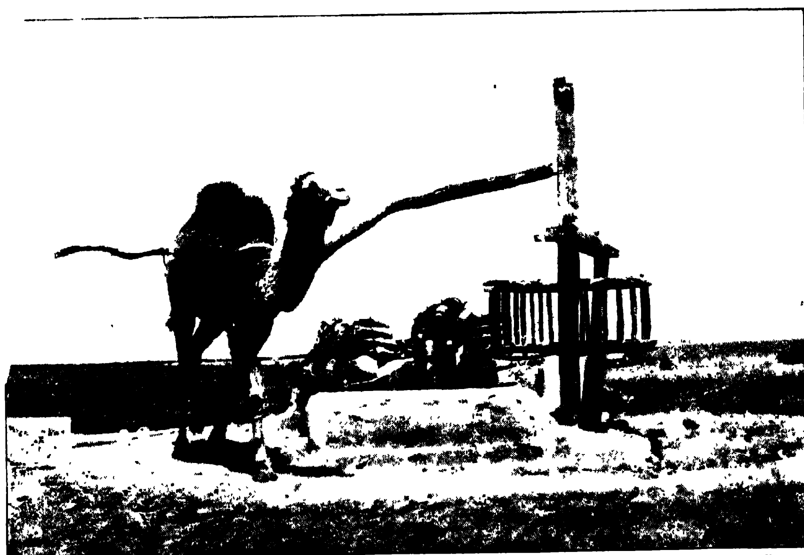
What about the work animals that give power to man in the cold deserts? The reindeer and the dog, of course! How well fitted they are for these cold regions! Reindeer are so strong that in Lapland they can pull sledges with 300-pound loads as fast as 15 miles an hour. They go for hours at a time without stopping. Their feet are so broad that they can move along easily on top of the snow.

Among the Eskimos of the North American Arctic the chief "beast of burden" is the dog. You will remember from the story in *Nature Peoples* how carefully



Frederick H. Lovejoy

Fig. 93. Dogs are still used to pull sleds over the snow



Ewing Galloway

Fig. 94. Irrigating by camel power in the Sahara Desert of Africa

the Copper Eskimos care for their dogs, for they depend on them to pull their sleds. From five to twelve dogs are harnessed together in a team (figure 93). For many hours these husky dogs (the dogs of one breed in the Arctic are really called "huskies") run over the ice and snow, pulling the Eskimo and his load, which weighs often as much as 1000 pounds.

Large, strong dogs are used today in still other parts of the earth to do man's work for him. In some of the towns of Belgium one frequently meets vegetable, milk, and other carts drawn by dogs. In parts of Alaska the rural-mail carriers of the United States Post Office now deliver mail in the winter by dog sleds. During wartime dogs are used as ambulance helpers, scouts, and messengers. In some places a kind of dog known as a bloodhound is used by police to trail people who are lost or who have run away.

We can see, then, that the ancient peoples of 5000 years ago had advanced in their uses of power over the simple nature peoples of the earth. They knew how to lift and pull, push and hammer, by using levers and inclined planes, wheels and axles, wedges and pulleys. They had also tamed the ox and the bullock, the yak and the camel, the elephant, the reindeer, the dog, and other animals, and trained them to pull and push and lift for them.

But there were still other power aids that they had discovered!

Other Natural Powers: Wind and Water

"There is power in wind!"

Who first said that we do not know. No doubt, as time moved on, many people, watching how the wind behaved, thought it out for themselves. Today every boy and girl knows that there is power in wind. We have only to try to stand up straight in a windstorm to know that there is power in it! Or to keep doors in our houses shut or pictures on the wall or papers quiet on tables. In a tornado, which is a terrific, whirling windstorm, whole houses are picked up and tossed about and smashed to pieces.

It is probably true that for thousands of years men were terrified by the winds; but, sooner or later, someone thought, "If I could only harness the wind and make it do my work!" Certainly the inventors among many peoples thought of it, for most of them did learn to make the wind move things for them.

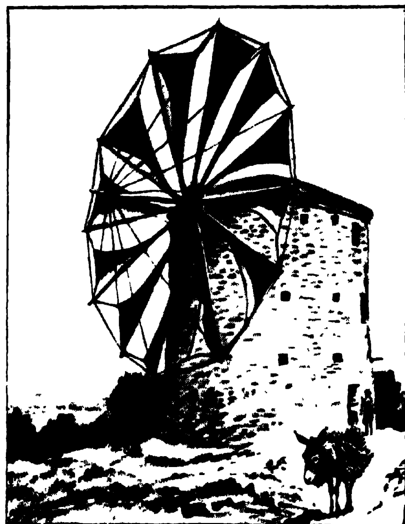
Perhaps the first use which people made of the wind was to move ships through the water. At least we know that they did that 6000 years ago, and no one knows how long before then. A thousand years before the Great Pyramid was built, Egyptian artists were drawing on their vases pictures of square sails that were moving ships. That tells us, of course, that their people were using sailing ships at the time.

Making Wind Turn Wheels: The Windmill

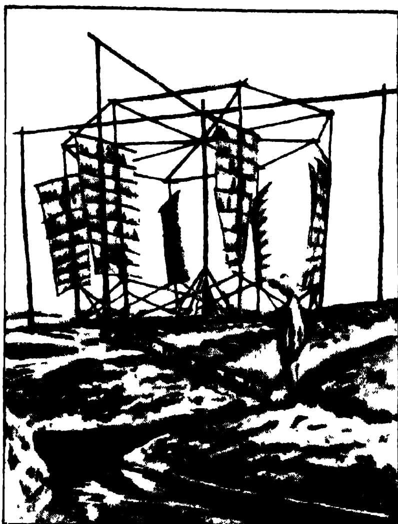
It was not until much later that people used the wind to turn windmills for power. We have searched and searched, but we cannot find any record that windmills were used by the Egyptians or the early Chinese or the Indians or the Greeks or the Romans or any other people until about 700 years ago. We do find in the history books the story of how a churchman, Dean Herbert, built a windmill on his land in England in 1191 A.D. It was used to grind corn. Notice the date! Not 1191 *before* Christ, but 1191 *after* Christ! That was 5000 years after men were sailing ships on the Mediterranean with wind power.

Perhaps you are thinking: "Can it be possible that for all those five thousand years men ground their corn by muscle power? Five thousand years of rubbing huge stones together to turn kernels of corn into flour? Five thousand years of backbreaking work of lifting water out of wells? Five thousand years of irrigating fields by muscles when all that time men might have made windmills to do these things?"

After all, a windmill seems to be a simple enough thing to make, once you understand that there is power in wind. Every child knows that if he runs with a paper pinwheel the air will make it spin round and round. And that's all a windmill is — just some large arms, or vanes, set high up in the air on a strong frame (figure 95). The vanes are slanted slightly to catch the wind and turn the wheel. As the wheel turns, the



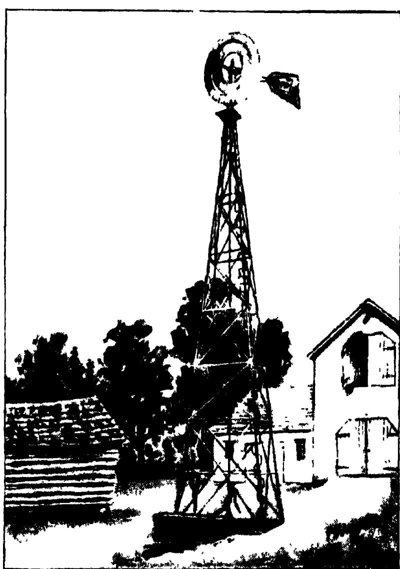
A windmill on the island of Samoa



A Chinese windmill used in irrigation



One of the early windmills for grinding grain



A steel windmill on an American farm today

FIG. 95. Windmills around the world

pole to which it is fastened turns also, and that does the work of turning the grinding stones (see these in the early mill of figure 95) or pumping water out of a well.

Of course windmills could not "work" all the time. They could only use the power in the wind when it blew. But windmills did increase man's power and they made it easier for him to do his work.

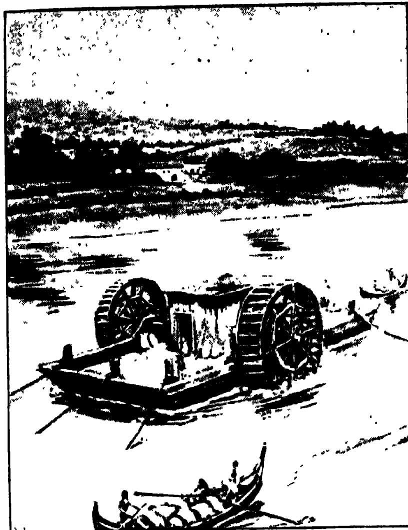
Making Water Turn Wheels

"There is power in moving water!" Anyone who has ever drifted downstream in a boat knows that; but it took a long time for men to make use of the idea.

Just as men learned how to make the moving air do their work, they harnessed the power in moving water. They did this by making the water turn wheels.

There are many stories about early water wheels, but we cannot be sure of their truth. We do know that 2000 years ago the Romans ground their grain on flat-bottomed boats. They anchored the boats out in a river where the current flowed swiftly. Figure 96 shows you such a boat. The grinding stones are in the cabin in the center of the boat. Two paddle wheels are attached to the ends of a long axle which is stretched across the boat. The water of the river moving along struck the paddles and turned the axle. The axle turned the stones and ground the grain. This invention was clever, indeed! No sweating slaves nor paid laborers: no oxen to be fed. The moving river did the work.

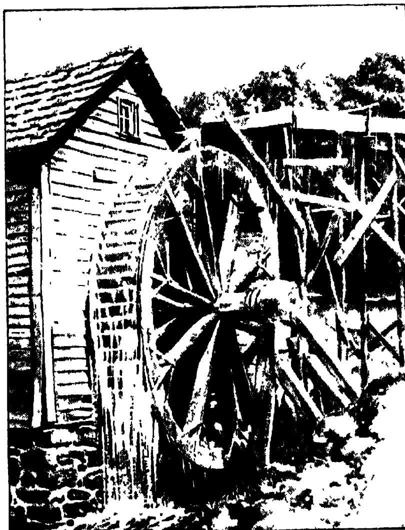
It is little wonder that every people who lived near rivers learned sooner or later to use water wheels. We



How an artist imagines the early Roman boat mill looked. Can you explain the picture?



Bamboo was used to make this great wheel which raised water to irrigate Chinese rice fields



An American water wheel of colonial days which made the power to grind the grain



Can you tell how the moving water turns these grinding stones?

Fig. 96. Water wheels around the world

can be certain that at least 100 years before Christ the Chinese were using them. Roman historians tell of some being used in Greece even earlier than that. Although we cannot prove an earlier date, it seems quite likely that the Egyptian engineers were building water wheels 2000 or 3000 years before that. If they built bridges, water systems, and the remarkable pyramids, they probably built a wheel with paddles on it and fastened it to a turning rod. To the turning rod would be attached stones to grind grain. That is all a water wheel doing work really is.

But these water wheels of the Romans did not furnish much power. Most of the water of the river was wasted, moving by on each side of the boat. In dry weather, when the water in the river was low, the wheels could not turn at all.

Gradually people began to see that by using the narrow places in the rivers where the water ran faster they got more power. Then, little by little, they began to build the water wheels on one bank of the river and to build a wall so that the water would flow by faster.

Later someone got the idea of letting the water drop down on the paddles of the wheel. The *weight* of the water as well as its movement turned the wheels even faster. There is an important scientific idea behind this: that a falling weight has great power.

That was true of the water wheel. Great masses of water dropped down on each paddle as it came up, forcing it down and turning the wheels. Round and round, faster and faster, went the wheels.

So water wheels were improved as time went on. Inventors learned that two things decided how much power they got from their wheels. One was the height through which the water fell. The farther it fell, the more power it had. The other was the amount of water. The more water that fell, the more power it gave. So they increased the width of the wheels and the number of buckets.

What One Big Water Wheel Could Do

Although engineers today are amused at the water wheels of our great-great-grandfathers, these wheels were a wonderful step forward over the muscle-power days of early times. Compare the amount of power of a man's muscles with the power of a 76-foot water wheel built in Italy about 1800. The wheel, running 24 hours a day, made 30 horse power; that is, as much power as 30 horses can make. Even a strong man would make only about one tenth of one horse power in an 8-hour working day. So the 76-foot wheel could do as much work as 300 men!

Another advantage of the wheel, of course, was that it could run for twenty-four hours without stopping. Except for a little oil now and then, it did not have to be fed! It needed neither rest nor sleep. At the same time moving water cost almost nothing, once the dam and dikes and wheel were built.

Do you think it is at all surprising that many inventors spent their whole lives trying to make better water wheels?

Very briefly we have told the story of power up to about 200 years ago. Until then all the kinds of power we have learned about were "natural"; that is, they were provided by things from nature.

Human muscles and animal muscles are nature power.

Moving air is nature power.

Moving water is nature power.

Those were all man had until 1700 A.D., about 200 years ago. But about that time he succeeded in inventing another kind of power that was to change men's lives in many, many ways.

Books You Would Like To Read

BAYNES, E. H. Polaris: Story of an Eskimo Dog. The Macmillan Company, New York. An exciting story of an Eskimo dog whose father and mother were of the train that drew Peary to the north pole.

BOYLE, M. E. Man Before History: A Short Account of Prehistoric Times. Little, Brown & Company, Boston. The record of man during the Ice Age and Stone Age traced through his tools, bones, and wall paintings.

CLOWES, G. S. L., and TREW, CECIL. The Story of Sail. Henry Holt and Company, Inc., New York. A history of sails from earliest times to the present.

DAVIS, M. G. The Handsome Donkey. Harcourt, Brace and Company, Inc., New York. The story of an Italian donkey that saved his master's life.

HADER, MRS. B. (H.), and HADER, ELMER. Midget and Bridget. The Macmillan Company, New York. Pleasant and unpleasant adventures of two small burros in Mexico.

HADER, MRS. B. (H.), and HADER, ELMER. Spunky, a Shetland Pony. The Macmillan Company, New York. A little Shetland pony has an exciting time, first working in a coal mine, later becoming a circus pony.

O'Brien, J. S. By Dog Sled for Byrd. Follett Publishing Company, Chicago. How an airplane base was established at the mountains near the south pole.

Ramée, Louise de la. A Dog of Flanders and Other Stories. The Macmillan Company, New York. A big dog helps his little master to deliver milk.

Wells, Rhea. Ali the Camel. Doubleday, Doran & Company, Inc., Garden City, New York. Adventures of Bali with his camel in Tunisia.

Wells, Rhea. Beppo the Donkey. Doubleday, Doran & Company, Inc., Garden City, New York. Beppo, the tiny donkey, has many interesting adventures living on the beautiful island of Sicily.

Wells, Rhea. Coco the Goat. Doubleday, Doran & Company, Inc., Garden City, New York. An interesting story of Garito the goat boy as he traveled about Spain with his goat Coco.



Fig. 97. Heron's steam ball entertained the wealthy men of Greece

CHAPTER XI

Man's Struggle To Invent Mechanical Power

There Is Power in Steam

YOU KNOW what happens when you heat some water in a teakettle until it begins to boil. From the spout of the kettle vapor will begin to appear. Look closely. Notice that the vapor begins just a little distance away from the spout; there is a "blank space" between the spout and the vapor.

That blank space is very important. It is not really a blank space, it is steam — a gas that the heating of the water has formed.

Look at a drop of water. Notice how big it is. Now if you could imagine how big 1644 drops of water would be, you could see what happens when one drop of water has been turned into steam. Scientists have shown that a drop of water when turned into steam fills 1644 times as much space. This increase in size is called "expansion." We say that the gas "expands"; that is, it becomes larger.

Now that is very important. Why? Because the expanding steam has power in it. It can make things move, and anything that will make things move will do work.

Let us show how this is true from the history of experiments with steam.

Heron's Experiments Long Ago

Even as long as 2000 years ago a Greek scientist named Heron, who lived in Alexandria, Egypt, discovered that steam would move things (figure 97). Heron fastened two little pipes to a ball. Then he connected the ball to a kettle by means of two other pipes. He filled the kettle with water and started a fire under it. The water became hot and formed steam.

The steam expanded; and as it expanded, it tried to get out of the kettle. Up the open pipes, into the ball, it went. More and more it filled the ball; harder and harder it pressed on the inside. We say that the "pressure" in the ball increased. Then some of the steam passed into the little pipes which extended outward from the ball. The openings were very tiny, but the gas could force itself through. As the water boiled in the kettle, more steam forced its way into the ball. Greater and greater became the "pressure." Faster and faster the steam pressed its way out through the pipes.

Then something unusual happened. The ball began to turn! What made it do that? The steam, pressing through the openings in the pipes, was forced out into the air. As this happened the pipes gave a kick back, and the ball turned. Then faster and faster expanded the steam and forced its escape through the pipes. Faster and faster turned the ball. Here, then, was proof that expanding steam would move things.

Heron was the first steam-engine maker because his "ball of the winds," or "steam ball," as it was called,

was really the first steam engine. It was only a toy, of course, and so far as we know neither Heron nor any other "scientist" of those days tried to build big steam balls. At that time the idea of building a huge kettle which would heat hundreds of gallons of water and do real work did not occur to men. Yet Heron had hit upon the idea that *there is power in steam.*

Heron's ball entertained the wealthy men of Greece for a while and then was forgotten. Indeed, it was not until 1700 years later, after 1600 A.D., that a number of men experimented with steam engines and finally made one which would move heavy things and do real work! No one person did it alone; many people helped. That has been the way of many inventions. One person gets an idea and tries an experiment. Then another person, seeing its success, gets to thinking about it and adds a better idea. Perhaps some years pass before a third person happens along, sees the experiment or hears of it, and thinks up an improvement. In the meantime nobody knows how many people have come close to this better idea and have just missed it! But sooner or later another thinking person comes along and gets just the right idea. Another invention is given to the people of the earth to help improve their ways of living.

After 1600 A.D.: Learning What Steam Would Do

During the 1400's and 1500's the people of Germany, Italy, France, England, and other European countries learned how to measure more exactly; how to make things more perfectly. As their knowledge

increased, more and more of them tried to make better tools, implements, and machines. They were especially interested in making a pump that would lift water for a considerable height. There was a special reason for wanting such a pump. The people in Europe, and in England especially, were beginning to burn coal instead of wood for their fires. They were also beginning to take the iron from the earth. As the workers dug the coal and iron from the mines, they became deeper and deeper. Then the rains would often come and fill the mines with water.

By 1600 the mine-owners in England were spending large sums of money to get rid of the water in the coal and iron pits. At first buckets were used; then the usual kind of pump worked by men. As the mines grew deeper, bigger pumps were made. Treadmills were fastened to these, and horses were used to provide the power. The horses moved the treadmill, the treadmill moved the pump, and the pump lifted the water out of the mine. This was a very expensive way to take water from the mines. One English mine-owner, a Mr. Back, had 500 horses pumping water from his mine. It cost $10 a year to feed and care for each horse; 500 horses cost him $5000 a year! No wonder Mr. Back and other mine-owners offered rewards for the invention of an engine that would run the pumps.

If this were a long history of the steam engine, we would tell of the many curious experiments that were made in the attempt to use steam. The first ones were known as "water fountains." There was the Italian

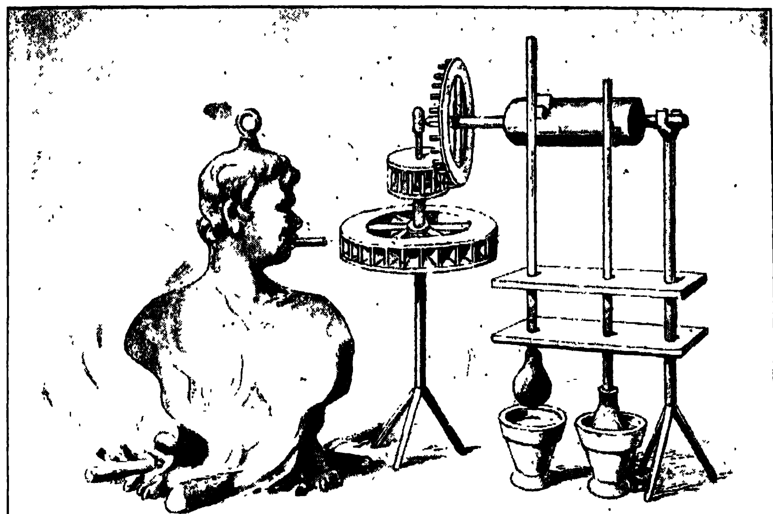


FIG. 98. Another amusing steam toy. This was made by Branca in the early 1600's

Porta's fountain (1601), which heated small amounts of water in a boiler and forced steam up through a pipe. Then there was a fountain made by the Frenchman De Caus, in 1615, which threw a stream of water quite high. Next, an Italian named Branca invented a queer toy (figure 98) which blew steam against a wheel and moved a little drug-pounding stamp up and down. But drug clerks could do that more easily by hand!

In speaking of these early "engines" we could not leave out the name of a British nobleman, the Marquis of Worcester, who in 1663 wrote a book called *The Century of Inventions.* In this he told of a fountain that he had made at Raglan Castle long before — in 1628. All we know of this fountain today is what he

said. According to his story it shot a stream of water 40 feet high. But whether or not it pumped water for any use, we do not know; for not one of his engines remains.

But these things of Heron, of Porta, of De Caus, of Branca, of Worcester, were all toys, mechanical toys! They would do *some* work, but so little of it! They would lift *some* water, but so little of it!

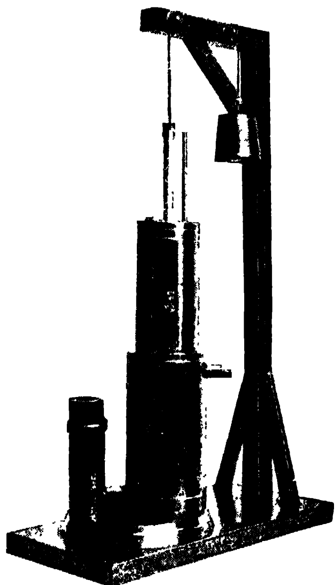
"Give us a big engine, a real 'water-commanding engine,'" cried the mine-owners as they watched their horses eating up the profits.

Pushing Pistons with Steam

It was a Frenchman named Papin who in 1670 got a new idea that was really to lead to the invention of the steam engine. He was the first man to think of using steam in a closed tube, or cylinder, and of making it work *inside* the tube, where its force would not be lost. This is the same idea as that of the peashooter, which every schoolboy knows today and which every boy probably knew in Papin's time.

Papin thought of using the old peashooter idea with steam. In the cylinder he placed a round, flat piece of metal which we now call a piston. This fitted just loosely enough so that it would move through the cylinder. When water was heated at the bottom of the tube, it formed steam; the steam expanded and pushed the piston before it up the cylinder. Of course when the steam cooled, water again took its place, and the piston dropped down again through the cylinder.

Papin's engine did not work very well, but inventors saw that the piston idea was a good one. They gave up trying to use the force of steam coming from spouts and turned to using pistons in cylinders. One thing was happening: men were beginning to see more clearly what steam could do.



Smithsonian Institution

FIG. 99. A model of the machine with which Papin amazed the Royal Society of England

Then came three Englishmen Captain Thomas Savery and Thomas Newcomen about 1700 and James Watt after 1760. These three men, taking advantage of what was known before their time, really succeeded in making a useful steam engine.

Captain Savery, working on Papin's idea, made an *air* engine. In a book called *The Miner's Friend*, which appeared in 1702, he described how his engine would pump water from mines. One mine-owner, after reading the book, paid Savery $250 to build him an engine. For a few days the engine pumped a little water without the help of horses. Then the steam pressure in the boiler became too powerful, and the boiler blew up. You can imagine how that experience discouraged both the mine-owner and Savery!

About the same time, however, Thomas Newcomen, an English blacksmith, also used Papin's idea of the piston. He thought of putting safety valves on the engine so that the steam could "blow off" and not "blow up." He made a pump which, although it was a huge, clumsy thing and allowed much steam to go to waste, really worked. Up and down it lumbered, hour after hour, pumping out gallons and gallons of water at every stroke.

James Watt: "The Father of the Steam Engine"

So matters stood for more than 50 years. Then came the real inventor of the steam engine. In the year 1763 a Newcomen pumping engine in the University of Glasgow, Scotland, got out of order. It was taken to James Watt, an instrument-maker in the city, to be repaired. Watt repaired the engine as best he could; but while he was doing so he began to study it to see if a better engine could not be made.

Watt noticed that in the engine which he was repairing the force of the steam was used to push the piston only one way. As the piston traveled back, much of the force of the steam was lost. Watt decided that he could make an engine in which the force of the steam would push the piston both ways. For nineteen years he worked at the task of making such an engine, and in 1782 he got an English patent on it.

Much of the time Watt was discouraged because he could not get good iron, good tools, and good measuring instruments. But his most difficult problem was



FIG. 100. The remains of a Newcomen engine erected in 1754



FIG. 101. In this workshop Watt studied and experimented

to find men who could do careful work. Workmen in those days did not know how to build engines. So for years and years his machines were not well-made. Nevertheless people began to see that his engine would really work. It was very large, it would move heavy things, and so it would do work for man.

In the 1780's and 1790's coal and iron mine-owners began to buy Watt's engines to pump water out of their mines. About the same time the first spinning and weaving machines were also being invented. Little by little the factory-owners began to see that Watt's engines could be set up in their factories to run their machines. Then other inventors tried to attach Watt engines to wagons to make railroads, and still others tried to drive boats with the engines. More and more of the new steam engines came into use.

Throughout the next hundred years Watt engines were improved until there came the wonderful steam engines of today. After 1860 an English inventor named Parsons invented a new kind of steam engine called a "turbine." It was named from the Italian word *turbino*, which means "whirlwind." The turbine brought about very great changes in the use of steam power, especially on ships. In such an engine a wheel is put inside a steel cylinder. On a ship the wheel is connected to the propeller, which is under the surface of the water. The wheel whirls rapidly from the force of the steam, making the propeller whirl about in the water so that it moves the boat forward.

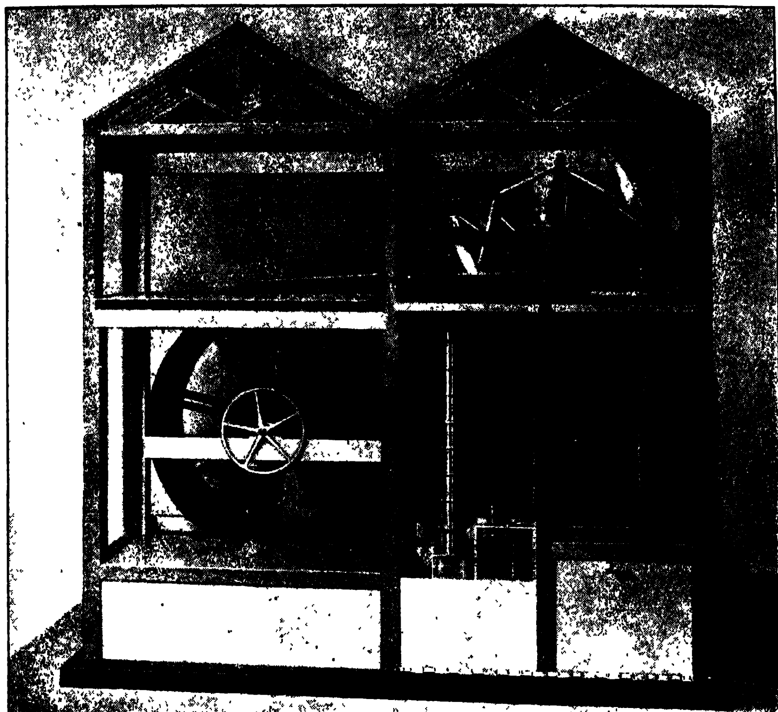


FIG. 102. A model of a steam engine that was built by Watt. It was called *Old Bess*

In 1897 this new kind of engine was placed in a small boat called the *Turbinia,* which broke the speed records for boats of all sizes. Today steam turbines run the fastest merchant and passenger ships, as well as the fast boats of the navy. Turbines have taken the place of other kinds of steam engines in the running of many of our big power plants.

James Watt is called the father of the steam engine

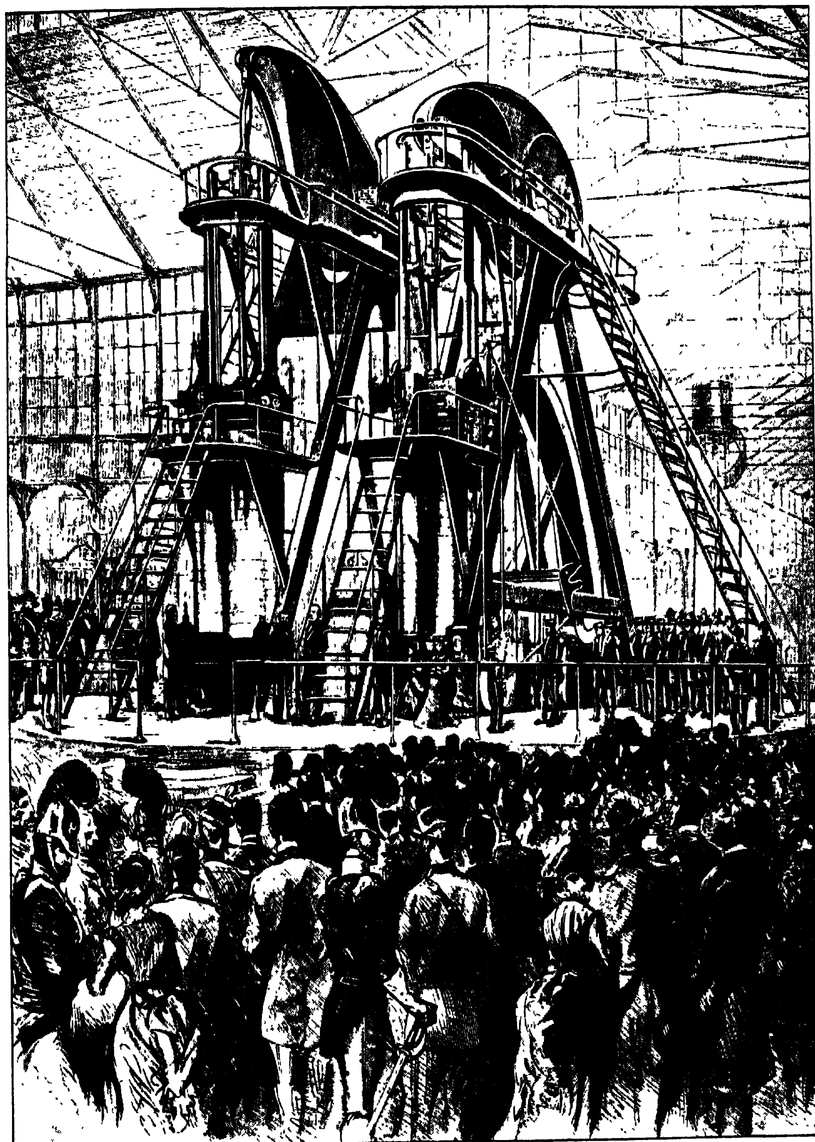
because his engine was the first really usable one. Even the engine that is made today is built on the same idea. Of course since Watt's time steam engines have been improved in many ways; but in the big locomotives that pull our trains, and in the engines in our power plants, there are cylinders with pistons moved by steam much as they were in Watt's engine over 150 years ago.

The Gasoline Engine

For a long time scientists had been thinking that there must be other things besides steam which would provide power for man's work. So when men had once learned that a piston could be pushed and pulled by putting steam in a cylinder, they tried to find other things that would move the piston. One of these which worked successfully was gasoline.

Water changes to steam when it is heated, but water is not burned. As you know, it expands; and when it is cooled, it changes back into water. Gasoline, however, is different. When it is heated, it too expands rapidly and becomes a gas; but when this gas meets the tiniest spark, it explodes.

Now an explosion makes power — sometimes very great power. When men discovered that, they tried to find a way to use the power that was made by the explosion. After many experiments they put the gasoline inside a cylinder and set it off with an electric spark. Sure enough! this "gas" engine had power; it could be made to work.



Harper's Weekly

FIG. 103. President Grant starts the great Corliss engine at the Centennial Exposition of 1876

For doing some kinds of work the gas engine is very much better than the steam engine. It is less heavy and bulky. A steam engine must have a heavy boiler, a large supply of water, and fuel with which to heat the water; hence it must be very large. But a gas engine needs only a supply of fuel; so it can be made much smaller. The gas engine has been found to be best for small boats, for automobiles, and for airplanes. Tractors too, like that on Mr. Mason's farm, are driven by gas engines. Indeed, the gas engine is used very generally nowadays in small machines.

We must end our short story of the invention of engines. We have seen that many hundreds of years passed while thinking men searched and searched for something with power to move things. Finally they found the way to use steam and gasoline. But even while they were having some success with the two kinds of engines, men were not satisfied. Better kinds of power must be found.

Books You Would Like To Read

BACHMAN, F. P. Great Inventors and their Inventions. American Book Co., New York. Stories of steam and electric power.

BARUCH, D. W. Big Fellow. Harper & Brothers, New York. The story of a road-making machine — a steam shovel.

BOCK, GEORGE, and ARTZYBASHEFF, BORIS. What Makes the Wheels Go 'Round. The Macmillan Company, New York. A book about machinery.

COOLIDGE, ANNE, and DI BONA, ANTHONY. The Story of Steam. The John C. Winston Company, Philadelphia. An answer to the question "How does the engine work?"

DOUBLEDAY, RUSSELL. Stories of Inventors. Doubleday, Doran & Company, Inc., Garden City, New York. True incidents and personal experiences of inventors and engineers.

EDELSTADT, VERA. A Steam Shovel for Me. Frederick A. Stokes Company, New York.

JONES, WILFRID. How the Derrick Works. The Macmillan Company, New York. An explanation of how the derrick works, with pictures to illustrate each step.

LENT, H. B. Diggers and Builders. The Macmillan Company, New York.

LENT, H. B. Full Steam Ahead! The Macmillan Company, New York. An ocean liner from bridge to engine room during six days of passage.

VAN METRE, T. W. Tramps and Liners. Doubleday, Doran & Company, Inc., Garden City, New York. An interesting story about the various kinds of propelling power - sail, steam, and motor; also the development from the galley to the motor ships, cargo ships, and de-luxe ocean liners of today.

CHAPTER XII

We Live in the Power Age

What Electric Power Will Do

IN CHAPTER after chapter we have seen man struggling to lift, to pull, to push, to pound, to dig, in order to do his work. Sweating, puffing, getting tired, wearing out, — all in the attempt to move a few pounds of weight.

But what a contrast is shown in the frontispiece of this book! What is happening? A man is sitting high above the railroad tracks on a seat on a steel crane. He moves a lever on his machine, and the enormous thing moves down the track and stops next to a freight car. He moves another lever, and a great magnet drops down and stops, not quite touching some long bars of steel. They spring up to it! They cling to it as though they were fastened with iron bars. The man moves still another lever, and the magnet is pulled up, the steel bars holding fast. The crane travels down the long yard and stops. One more movement of the lever, and down drop the bars. All this heavy work has been done by one man and without his moving more than the muscles of his hand and arm.

What is this power behind all these astonishing things? Probably you know without our telling you. It is *electricity*. All around us are examples of the ways in which electricity works for us today. In fact,

electricity is used so much that we often forget what an important part it plays in our lives.

The authors of this book live for part of the year on a mountain in the Catskills of New York State. We depend almost completely on electricity in order to live there. Our water is pulled up from a well 320 feet deep by an electric pump. Our light is electric. The cooking is done with electricity. The refrigerator runs by electricity. We telephone by means of electricity. Our radio runs by electricity. We warm the house by means of electricity.

Days and weeks go by without our thinking of the electricity. Then, perhaps, — as happened one night not long ago, — a heavy storm comes, and the electric power goes off in our hamlet! Next morning we suddenly realize what has happened. There is no water for bathing or for the morning coffee! There is no heat! We go to the neighbor's well for water. We heat water and prepare food in the fireplace. We use candles or kerosene lamps, just as people did long ago. We get along without ice.

Then the power "goes on" again, and we are back in the age of electricity, and mechanical slaves are doing most of our work for us again. It is then that we people of the twentieth century begin to understand how different our world is from that of our great-grandfathers of less than 100 years ago. And this world has changed chiefly because of the discovery and use of that great force which we call electricity.

Magnets

Let us come back for a bit to the huge crane that picked up a whole load of steel bars and carried them across the yard. Those heavy steel bars just jumped up to meet it and clung to it as it moved along. What was it that did this work without men or animals and without things to hold the bars together? It was a *magnet*!

No doubt you know what a magnet is. If you do not, you can buy a little one in a 5-and-10-cent store and experiment with it. It will pick up tacks and some other little metal things. It will do more than that for you, too. If you rub something of iron on the magnet, the iron thing will also be a magnet. We say that the iron becomes "magnetized."

Magnets have been known for at least 2000 years. In books written by the Greeks of that time, stories were told of "black stones" that would draw pieces of iron up to them. These stones had been found near the Asia Minor coast of the Mediterranean Sea, in a region called "Magnesia." So the Greeks called them, in their language, *magnetes lithoi*; that is, "Magnesian stones." As time passed, other people named these stones from the Greek word *magnetes*. When the English began to speak of them, they called them "magnets."

The Chinese, the Hebrews, and, perhaps, other ancient peoples had also found magnetic stones in their country. They had discovered something very important about them. This was that any magnet if

hung by a silk thread in the center would turn round until one end pointed north. After this discovery they made "compasses" to guide their ships at sea. Do you remember that in *The First Book of the Earth Workbook* you learned how to make a compass by rubbing a needle on a magnet and then sticking the needle through a cork? As you know, when you floated the cork in a pan of water, the needle always pointed north.

Because the black stones always pointed north and could be used to "lead" people where they wanted to go, people called them "leading stones" or "lodestones." In ancient times the Chinese, the Greeks, the Romans, and others knew how to use them. Still later, inventors among the Finns, the Italians, and many other peoples also discovered them. The sailors of Italy and Spain and Portugal had such lodestones for compasses in the 1400's, and it was these that helped Columbus and the Cabots to discover America in the 1490's.

During all those hundreds, even thousands, of years, however, people did not learn that magnets had something to do with electricity. When they finally discovered that, great changes began to take place. Let us go back again and see how they discovered electricity.

Magnets and "the Electric"

For no one knows how long, people had known that there was a mysterious power in nature. They had never understood it, and, of course, it did not occur to them to make it work for them. As early as 600 B.C.

Thales, a Greek scientist, had discovered that if a piece of amber were rubbed with a cloth, things of little weight would cling to it. Try the experiment yourself with some beads or something else of amber. You will find that the rubbing sets up a strange power in the amber that makes it attract, or draw, pieces of paper to it. We say that it has an attracting power.

It was 2500 years ago that Thales discovered the attracting power of the amber. Then the idea was forgotten. Not until about 1600 A.D., nearly 2200 years later, was it discovered all over again. At that time an English scientist, Dr. William Gilbert, also found that rubbing amber and certain objects together would create this attracting power in them. Now the Greek word for amber is *elektron*, so Gilbert called the unknown power "the electric." As time went on, the name continued to be used and has since become *electricity*.

Like many other scientific men, Dr. Gilbert wrote a book about his discoveries. This was read and talked about by other scientists, and with electricity, as with steam; one inventor taught another a new idea, and he in turn would think up an even better invention. We might say that one man's idea led to another.

More time passed and more people became interested in scientific experiments. In England some of these scientists formed a secret society called the "Invisible College" and met behind closed doors to discuss their ideas and their experiments. To this day this society is the honored scientific organization of England

and is known as "The Royal Society." From the discussions of these men came many new ideas.

Meanwhile new ideas about "the electric" were coming fast in the minds of people of other countries. In 1664 a German, Otto von Guericke, made a machine that spun a ball of sulphur against a silk cloth, making electricity and a roaring, crackling sound in the ball. And — wonder of wonders! — in the dark this sulphur ball glowed with light! That was a new discovery — electricity giving light!

Von Guericke discovered not only how to make electricity by a whirling ball; he also discovered how to send it over a silk thread for the distance of about a yard.

Playing with Sparks

More books began to appear about these strange things called "electrics," and as people read them they began to watch, to observe things that happened to them. They began also to ask more questions about *why things happened*, and they sent their questions to the well-known scientists.

"Why does one's hair often stand up straight when he runs a comb through it?"

"Why do I get a shock in my fingers when I walk across a thick rug and put my hand on the doorknob?"

"It's 'the electric' in it," was the answer.

Ladies who wore silk dresses told of sparks coming out of them.

"It's 'the electric' in them," was the explanation.

Of course that was not really an explanation, but it did show that people were becoming very much interested in "electrics."

More time passed, and the 1700's came. People talked, and the scientists worked at their ideas; but, as in the case of the steam engine, few took them seriously. Business men and kings and princes laughed at men who had nothing better to do than to play with toys.

Sending Shocks for Long Distances

One of these "playing" scientists was the English schoolmaster Stephen Gray. One day Gray was experimenting with a wooden stick which had an ivory ball at one end. He found that when he whirled a glass cylinder around in his hands he became "charged" with electricity. Then the ivory ball at the end of the long stick would draw a small piece of metal to it.

"'The electric' can be sent over wood," said Gray to himself. He tried a piece of wire. The electricity traveled through the wire to the ivory ball at the end. He took a longer wire; still it traveled. Then he used a silk thread, a very long one. Even then the electricity traveled.

Before Gray died, which was soon afterward, he had succeeded in sending electricity through wire the long distance of 866 feet -- the length of two city blocks today! This was in 1730, about 200 years ago. For his discoveries and inventions Gray is regarded as one of the greatest of the early electrical engineers.

Making "the Electric" Move Things

Of course to most people all this playing seemed utter foolishness. They said to the scientists: "What if you can send the 'electric' over a wire 800 feet long! What of it? It doesn't do anything for us. Now, there's the water engine. It can do work! What will your electric do?"

The scientists went on with their experiments, and, little by little, they began to make the electric "do" something. We cannot tell of the many, many men who helped to find out the way, but a few of them were very important. There was a Scottish monk named Gordon who succeeded in making the electric ring a bell. The bell gave just the faintest *ding* and the faintest *dong*, but it did ring!

Later, Gordon did get an idea of how to make a motor. We could scarcely call it a motor today, just enough to make a light wheel spin around, but it did "do" something. "More toys!" thought the people of his time.

In 1745 a Dutch scientist of Leyden, Holland, whose name was Pieter van Musschenbroek, accidentally discovered something still more important about electricity. Pieter put some water in a jar and connected the jar with an electrical machine. Then he turned the machine, hoping to charge the water in the jar. After a while he put his hand on the jar. *Bang!* went a shock through his body, and the next thing Pieter knew he was picking himself up on the other side of

the laboratory. "Electricity in large amounts? Well, there it is!" thought he.

Later Van Musschenbroek repeated the experiment, and more scientists followed with others. Thus, nearly 200 years ago, scientists learned how to store up electricity in glass jars. Later these jars came to be known as Leyden jars.

But don't miss the important point! A fairly large amount of electricity had been stored in those glass jars. There was enough to knock a man down! Now inventors began to think: "If you can give a man a shock big enough to move him, you can do other things with electricity as well. You can use it *to do work*!" That was the idea that was taking hold of men's minds; they were really on the trail of the secret of electricity.

Benjamin Franklin Flies His Kite

As you read more of the story of our country you will often meet the name of Benjamin Franklin, for he played a large part in its history. Franklin was an astonishing man. There seemed nothing that he could not do, and he seemed to succeed at everything in which he became interested. And he became very much interested in science and invention; indeed, he was really America's first inventor.

It happened that in 1746 an English friend brought a Leyden jar to America and showed it to Franklin. Franklin immediately became quite excited about Leyden jars, made some himself, and did many experiments with them. With each experiment he seemed

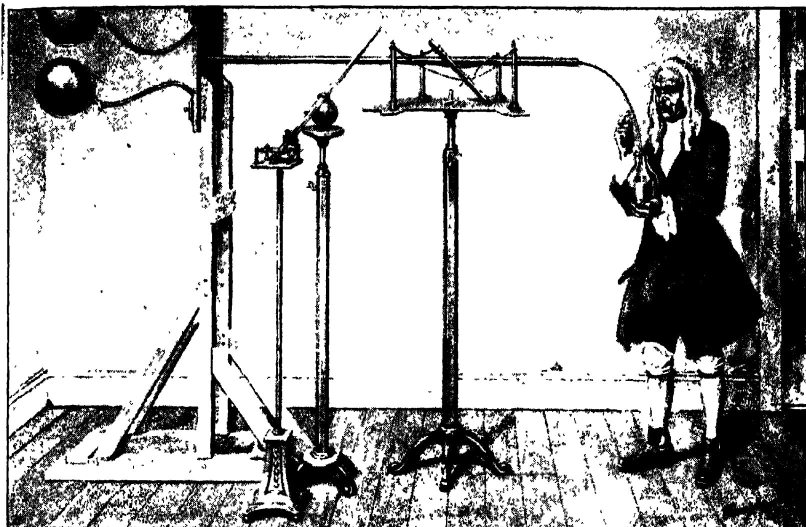


FIG. 104. Pieter van Musschenbroek starting his experiment



FIG. 105. Franklin making his famous kite experiment

to discover new ideas. For one thing, he learned that you could store more electricity if you put several Leyden jars together. The story goes that he proved this by sending a current of electricity through a turkey standing some distance away. The current killed the turkey instantly.

But Franklin is remembered more for his famous experiment with the kite and the key (figure 105). One evening in June, 1752, he and his little boy went out in a thunderstorm in the city of Philadelphia. There they flew a silk kite up into the sky. To the end of the string was tied an iron door key. Around his hands Franklin wrapped a silk handkerchief to protect him from a shock, since silk is not a conductor of electricity.

For some time, as they watched, nothing happened. But soon the kite string became wet. Then *flash*! went a zigzag streak of lightning through the air! *Crack*! went a spark at Franklin's hand as he touched the key.

"I was correct," said Franklin. "The lightning of storms is electricity!"

Other scientists had thought of this before, but Franklin *proved* it. Later he proved it still further by charging a Leyden jar with electricity from a thunderstorm. The lightning flash was simply a huge spark like the one which Franklin got when he discharged a Leyden jar.

That same year Franklin put an iron "lightning rod" on top of his house. The rod attracted the lightning, which passed along it and went into the ground,

instead of striking and burning the house. After that time people began to use such tall pointed rods, or lightning conductors, not only in America but in Europe as well. Have you ever seen them on barns or houses?

What Made the Frog's Legs Kick?

Thirty years passed after Franklin's discovery. Then one day in 1786 another accident happened, and some more important ideas were found out.

Dr. Luigi Galvani of Bologna, Italy, was working in his laboratory. He was cutting up a dead frog. Many, many times before, Dr. Galvani had cut up frogs and nothing unusual had happened. But on this particular day another person in the laboratory had turned on a friction machine that was near, and the handle of Dr. Galvani's knife just happened to touch a wire of the machine. To his great surprise the legs of the dead frog kicked!

"What was that?" the startled Galvani asked.

Again and again he tried the experiment, and again and again the legs kicked.

Immediately Galvani told other scientists about his discovery, and as usual there was much excitement over it. Many new ideas were suggested.

"Electricity must be life itself," said Galvani.

"Not at all," said other scientists, and a great debate started up all over Europe.

But Galvani went on with his experiments and later, like the earlier scientists, he wrote a book in which he told of his work with dead frogs.

Luckily for us, Galvani's book came into the hands of a man who did not agree with him. This was an Italian scientist named Alessandro Volta. Because Volta did his own thinking and would not take other people's ideas without having them proved, he hit upon the next important idea about electricity.

Volta's point was that electricity could be made by bringing together two different metals. "You can prove this for yourself," he said. "Put a silver coin under your tongue and an iron key on top of it. If you bring the two together at the end of your tongue, you will feel the electricity."

Volta arranged piles of objects of metal, such as copper and zinc, with strips of wet paper between them. He found that a wire attached to the top and bottom of the pile gave one a severe shock. Then, after many more experiments with various kinds of acid, he found that if he wet the paper with sulphuric acid it would give a much greater shock. But, still more important, he learned that if he put metal strips of silver and zinc in several jars of acid and connected them with wires, he could make a very strong current of electricity.

Of course all these experiments did not take place at once. It took Volta four years to learn that this new idea was true.

"More play and nonsense!" thought the business men and the kings. "Electricity still cannot do man's work. Not until it does, is it important to know about."

Oersted Sees that Magnets Have To Do with Electricity

Nearly twenty years more pass. Then one day in 1819 another accident happened, and this time another watchful and thinking man was there to see it. While Professor Hans C. Oersted of the University of Copenhagen, Denmark, was showing his class how an electric battery heats wires, he picked up a compass that was lying near to move it out of his way. As he did so, the compass passed under the wire of his electric battery. Suddenly the needle of the compass jerked!

To most people that movement would have meant nothing; but to Oersted, who was always on the lookout for such things, it was very important. Again he moved the compass under the battery wire. Again it moved! Then he took the wire off the electric battery and moved the compass under it. The needle stood still! He fastened the wire to the battery, and again the compass needle moved!

Success! Oersted had proved that an electric current did work like a magnet. There *was* a connection between magnets and electricity.

Once more the story of invention was to be repeated. Oersted kept on experimenting and then wrote a book telling the story of what he had found. Printed books were now becoming more common; so scientists soon read of Oersted's discovery. At once there was discussion and debate in every university and learned society in Europe. As was to be expected, new discoveries led, step by step, to more and better inventions.

Among those who read about Oersted's discovery was André Marie Ampère, a young French professor in Paris. He began to experiment with currents in wires, and within the astonishingly short time of one week had improved on Oersted's work. He showed that if electricity goes through a coil of wire, the coil itself works like a magnet; such a coil of wire will then swing around toward the north like a compass. Here was the last proof that was needed to see how electricity and magnetism were related.

Still other scientists went to work on electricity. There were too many for us to mention them here, but each of them added something to the ideas which were known before them. A few have been remembered more than others because their names are used in measuring electricity. Have you ever heard of *volts* or *amperes*? As you can see, these have been taken from the names of scientists.

But 1830 came and went, and still electricity did nobody's work. It would move things — by jerks and for a short time. Galvani and Volta and Oersted and others before them had proved that. But how to harness it so that it would move big things, heavy things, and keep on moving them — that was the problem.

Michael Faraday Makes the First Real Dynamo, 1831

It was Michael Faraday, a poor English blacksmith's son, who began to solve that problem for the world. For years and years he worked as a young assistant in the laboratory of the Royal Society. There



Fig. 106. Professor Oersted discovers that an electric current works like a magnet



Fig. 107. Faraday planning his experiment to make electricity

he learned what earlier scientists had discovered about electricity. He knew what Oersted had found out — that when a needle was moved by an electrical current in a wire, the electricity made it turn in some way about the wire.

"It *turned* about the wire! Ah," thought Faraday, "perhaps the *turning* is the important thing."

In 1821 Faraday had set up experiments to find out. Month after month he studied the problem. People had succeeded in making electricity move things. Could he also make a moving thing produce electricity? He would try. Years passed — five, six, eight, finally ten years.

Then in 1831 Faraday got the idea. He hung a large round copper plate between the ends of a big magnet and fastened an electrical measuring instrument to it. Before the eyes of the members of the Royal Society he whirled the disk swiftly by turning a crank. The scientists looked at the measuring instrument. Sure enough! Electricity was being made in the copper disk!

At last man had discovered how to make electricity by turning something. One wire lying beside another or a magnet lying beside a still wire would do no good; but a turning wire, or copper disk, beside the magnet — that did the trick of *making* electricity.

One hundred years have passed since that famous day when Michael Faraday whirled his copper piece between the poles of the Royal Society's big magnet. Crude it was, indeed, that first electricity-making

machine which we now call a "dynamo"; but, as years passed, other inventors and mechanics began to improve on Faraday's idea.

An American named Joseph Henry made a magnet that would pick up several pounds of iron. Some people said it would lift an anvil! Another American, a poor blacksmith of Vermont, named Thomas Davenport, built a motor that would work. He drove a little toy train over a track and showed how it would do better than steam engines. Ten years later, in 1847, a third American, Moses G. Farmer, built an electric car that would carry two passengers (figure 108). Year after year other inventions came. Steadily the dynamos and the motors grew bigger and more powerful.

Before 1880 the electrical engine was pulling cars on tracks, lifting things, and pounding things. In 1879 a German, Doctor Siemens, electrified a third steel rail lying on the ground between two rails of a railroad track. This power pulled a train of three cars and twenty passengers over the track at eight miles an hour. At last electricity was really doing work!

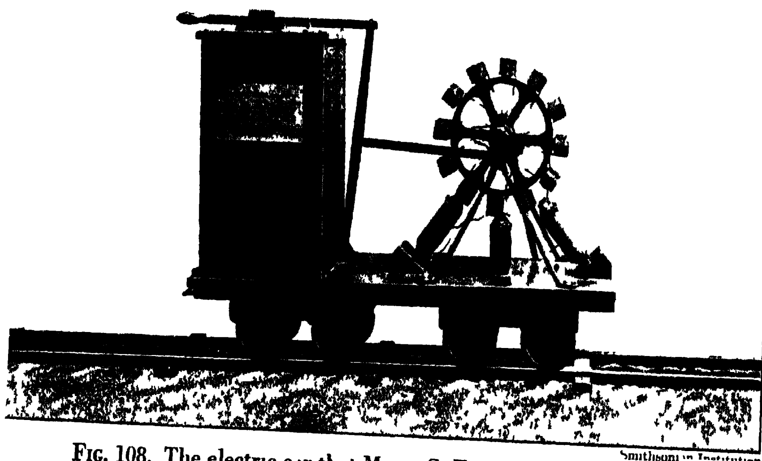
So it was that many inventors helped to turn these ideas into machines and dynamos and motors that would work. Perhaps the most famous of these was Thomas Alva Edison. No other man in the world succeeded in making so many electrical inventions as did Edison. It was he who discovered that electricity could be used for light. His "Jumbo," a machine which was shown at the Paris Exposition of 1881, weighed 2700 tons and made enough power to light 1200 lamps.

Sending Power a Long Way from the Engine: The Central Power Station

The story of electricity could not end without our thinking of the one great advantage which electricity has over other kinds of power; that is, that it can be used far from the place where it is made. Think of a man lifting or pushing or pounding or pulling something. His muscles make the power, but he must use that power where he stands. He cannot send it somewhere else. So it is with an animal turning a wheel or carrying something: the power of his muscles can do the work only at that spot.

Much the same thing was true of the windmill and the water wheel. They would turn axles that were fastened to them, so the power that they made could be used through the length of the axles. Inventors learned how to fasten gears on these axles and turn other axles with the gears. By fastening grinding stones to the wheels the power made by the windmill and the water wheel could be sent a short distance, perhaps 50 feet or even 100 feet. When the steam engine came and belts and gears were improved, the power from the engine could be sent a little farther.

But what a change came about when the scientists and inventors learned that electricity would flow through a wire! Greater and greater became the distances over which the current could be sent. At first a half mile! Next three miles! Then ten miles! Steadily the distance increased.



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FIG. 108. The electric car that Moses G. Farmer designed in 1847



New York Edison

FIG. 109. A drawing of the first Edison electric-lighting station in New York

Then, in 1881 and 1882, the idea grew in Thomas Edison's mind that large amounts of electricity could be made in central power stations and sent long distances over wires. Edison built a huge dynamo in New York City, and from one central building houses were lighted by electric lamps miles away. In other places dams were built on rivers, and huge water wheels were built under them. The water fell on the wheels hour after hour, never stopping. Round and round spun the wheels at terrific speed. Above the water was the power house. There the axles of the wheels turned the axles of dynamos, making enormous amounts of electricity. Out over copper wires strung high above the ground went the current. Into distant cities and towns and lonely farms it came.

As we write this book the engineers have learned how to send electric power over wires for a distance of 600 miles. And they tell us that it will be possible to make that distance even greater. There seems to be no end to what man will be able to do with power.

You see, then, how during hundreds of years many inventors discovered how to make electricity and, with it, to do many kinds of work for man. It not only lights our homes and our streets; it also makes large amounts of power for us. It helps to transport us and our goods quickly. It warms our homes in winter and cools them in summer. It runs many of the machines in our factories and the presses that print our newspapers. It makes our moving pictures and lights the



Fig. 110. One of Edison's early electric locomotives



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Fig. 111. One of the first electric streetcars

stages in our theaters. It makes possible the entertainment and the news that we get from the radio.

All these things are possible because the power can be sent over wires to places far apart. Today power stations, where electricity is made, are being built in nearly every part of our country. Power is being sent over wires for long distances. Some scientists are thinking now that they may find a way to send electrical power even without the use of wires! Man is looking for still better kinds of power.

Books You Would Like To Read

BROOKS, E. S. The True Story of Benjamin Franklin. Lothrop, Lee & Shepard Company, Boston.

KEELOR, K. L. Working with Electricity. The Macmillan Company, New York. A book of lights, bells, magnets, and messages. Experiments with electricity.

LACEY, I. B. Light Then and Now. The Macmillan Company, New York. A picture story of light from prehistoric times to the present.

LEHMANN, H. G. Shop Projects in Electricity. American Book Co., New York.

MORGAN, A. P. A First Electrical Book for Boys. Charles Scribner's Sons, New York.

MULLEN, S. M., and LANZ, M. S. This New Age: Sketches of Activity in Science and Industry. D. Appleton-Century Company, Inc., New York. Getting materials, conquering distance, giving wings to the world, looking forward.

SIMONDS, W. A. A Boy with Edison. Doubleday, Doran & Company, Inc., Garden City, New York. A story of one of our greatest inventors told by the man who was his assistant during the years of the discovery of electric light.

PART VI

Man the Toolmaker

AS YOU looked at the giant power-makers around you, did you wonder how people could build such huge things? Perhaps you said, looking at figure 103: "There is an engine that reaches almost to the ceiling. That boiler must be very, very strong to hold the steam which presses with such great force against its sides. What is it made of?" Or, looking at heavy cranes that pull things up and down, you thought, "What materials will be strong enough to do such heavy work?"

Perhaps you were thinking not only of the materials but of the "tools" with which machines are made. How did workmen put that engine together? They could not have done it with screw drivers and hammers, crowbars and rollers. That enormous hole in the engine! How was it bored? Certainly not with a hand drill! You laugh even at the suggestion.

You are right. There must have been tools and machines larger and stronger than the engine, in order to make it and put it together. What are they?

These questions lead us directly to the next important part of the story of man at work. That part will tell us about the materials out of which our new world of power and machines is made and about the giant "tools" that men used to make them.

In order to understand these things, let us go far back in history and see the materials and tools used by men in earlier times than ours. We shall see how nature peoples made things long, long ago, and how many of them still use the same tools today. We shall ask how the Egyptians and Chinese, the Greeks, the Romans, and the early Europeans made things. In short, by studying the history of materials and tools we can see how man finally invented the astonishing things that we have today.

Man Was the First Toolmaker

Let us turn the hands of the history clock as far back as the fossils will let us go. From them we can tell that even 100,000 years ago men were toolmakers. By cutting stone or wood into special shapes they were trying to increase the power of their arms and hands and fingers, of their backs and their legs.

For millions of years animals had also been on the earth, but they did not invent tools. A very few of them knew how to *use* tools but not how to *make* them. For example, in a zoo today one often sees apes using stones to crack nuts, but never do they make the stone over into a special tool to do the special job of nut-cracking! There is a story of an orang, a kind of ape, in the London Zoo who twisted some wire into a file, sawed his way out of his cage, and escaped. But this is the only record we have ever found of animals making tools. That kind of invention was left for man to do. He was the first toolmaker.



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FIG. 112. A warrior who lived in the New Stone Age. His tools and weapons are of rough stone

The Tool Chest of the Stone Age Peoples

Let us look next at the "tool chest" of nature peoples who lived in the New Stone Age. That was perhaps 10,000 years ago, perhaps 15,000. One glance at figure 112 and we wonder how those blunt, rough things could ever be used as tools. Yet, so far as we can find out, those were the only tools men had before

the days of ancient Egypt. Of course it might be true that their tools and weapons were made of wood, since wood was near at hand and could be made into things. But wood rots away and leaves no records to tell the story, so we do not know. We do know, however, that there was not an iron or steel, copper, or bronze tool among them. The name "Stone Age people" fits them well.

Here are some of the things which a Stone Age man might have had in his tool chest if he had one:

Stone axes to chop down trees.
Stone knives and saws to shape crude dishes of wood.
Stone chisels and scrapers to make the dishes smooth.
Stone hammers to pound things.

By the New Stone Age men were using a very hard stone that broke off in sharp flakes shaped like shells. This stone is called "flint." Nature peoples in all the continents learned to use flint for tools and weapons. The man held the piece of flint in one hand and knocked off its corners and edges with a stone tool. With other tools he pounded and chipped and scraped and polished the flint until it was smooth and ready to use.

Were there no iron tools at that time? So far as we can find out from the story told by the fossils these people had no iron. But these Stone Age people were to invent something during this time that would prove to be one of the greatest inventions in man's history on earth. Let us see what that was.

CHAPTER XIII

Man, the Fire-Maker

Fire-Making Was the Great Invention of the Stone Age Men

PERHAPS YOU are saying: "Fire-making a great invention! Why, fire-making is the simplest thing we do!"

You laugh as you give some examples: Strike a match, and there is fire! Snap a cigarette lighter, and — fire! Turn a button on the gas stove, and — fire! Step on the starter of an automobile, and fire starts the engine. And — well, what's the use of adding more? Everybody knows that fire-making is the easiest thing we do.

We shall agree that that is true today. But let us go back to a very, very long time ago, when people did not know what fire is and what it does. We shall make up a story of fire-making that will give you a picture of the way man might have discovered it. Our story will be short, but it is what the scientists think might have happened.

A Time when Only "Nature's" Fires Were Known

Onk (we'll call our Dawn Man that, just so as to have a name for him) is walking through the forest, club in hand, looking for animals to kill. Onk's family



FIG. 113. Onk watches the strange Fire Beast with wonder

is very hungry, and he must find food soon. Suddenly it becomes dark in the thick forest, although only a few moments ago the sun was shining brightly. A gray covering has moved over the sun, up there in the sky. Suddenly a terrible cracking and rumbling passes through the air, and Onk stops and looks up.

The Great Animal up there is angry again, he thinks. What have we done that is wrong? Onk waits under a tree. A blinding streak of light zigzags across the sky and strikes the very tree under which he stands. Onk is thrown to the ground. His body tingles; then it pains terribly; and suddenly all is dark.

A little later Onk wakes up and slowly raises himself from the ground, feeling of his body. It still tingles and hurts, but no bones are broken.

Now all around him, where it had been dark, it is light. A roaring, crackling sound greets his ears, and his body feels warm, almost as hot as at noon. What

has happened? And what is happening to the big tree under which he was standing when the Great Animal knocked him down? A strange beast is in it, crawling up and down around its branches. Like an enormous bird is this beast, with its wings spread out over the tree, and its huge claws stretching out now on this branch and now on that one. All the afternoon Onk watches the strange bird eating up the tree. Then he looks up at the sky and sees that night has come.

But now Onk notices something strange. Near the tree with the Light Beast in it everything is bright, although it is dark all around. Here and there among those distant trees pairs of little balls of light shine out. He knows what they are — the eyes of his enemies, the animals of the forest. He watches, knowing that they see him and are waiting to devour him. But for the first time they stay away among the trees! Why is that? Ah, they too are afraid of the Light Beast. Onk stays as close as he can to the tree, knowing that he is safe when the Fire Beast is there.

Branches now crash and fall to the ground, sending up many little light beasts. This is strange, indeed! But the strangest thing of all is that as he eats the trees, this queer-shaped animal itself gets smaller and smaller. At last, when the tall tree is a little stump and black piles of things are lying all around it on the ground, the beast disappears. All is dark once more.

Now Onk hears his enemies, the wild animals, crawling toward him among the trees. Danger is near; so he climbs a tree for the night. Next morning, when the

sun comes up and all is light, he climbs down and goes to find his family to tell them of the strangest happening of his life.

No doubt Onk and his family spoke to one another in their grunt language, finding many different ways of explaining what had happened. The thunder was the commands of an angry animal of the sky. The lightning flash, setting the tree afire and burning it up, was to them a great beast, or perhaps a terrible bird. They would watch now to see if he came again; then they would know more about him.

And, of course, the lightning did come again, striking trees and setting fire to them. Little by little these dawn people of a half-million years ago learned to expect what would happen. They saw that when the beast was eating up the tree, the air all around the tree was light; but that as the tree disappeared, the animal also disappeared, and there was less and less light.

There were other strange and wonderful things about the Light Beast. If you went and sat near him you would feel warm, often warmer than on a sunny day in an open space. But if you went too near and touched him — ah, that was bad! He was not kind then. He would bite quickly, before you could draw your hand away; and for days your hand would sting and hurt at the red spot where he had bitten you.

Perhaps best of all, however, was that you could lie down near the tree where the Light Beast was. There you could sleep safe and sound all night long without

having to worry that the forest animals would attack you. He would certainly protect you, for the forest animals were afraid of him.

Thus as time went on and the Fire Beast crashed down into the forests again and again, Dawn Men learned that even though the Fire Beast was an animal to be feared, there were some ways in which he helped them.

Another Discovery about Fire

Then, one day, by another accident (isn't it interesting that it was nearly always an accident that taught men a new idea?) Onk and other Dawn Men discovered another thing that the Fire Beast would do.

How that accident happened, and to whom it happened, and how many times in different places, we can only guess. But let us imagine again that one day after the Fire Beast has struck the forest and eaten some trees, Onk and his family are poking around in the piles of ashes. Suddenly Onk draws his hand back quickly. The beast is still there on the ground, for he has bitten Onk's hand.

Onk looks down again. Among the ashes is a deer that the Fire Beast has touched but not eaten. Onk goes nearer and touches it. The flesh is soft, but Onk's hand stings with the heat still in it. To soothe his aching fingers, he puts them into his mouth and sucks them. With the first touch on his tongue a look of surprise goes over his face. What a new taste! It is somewhat like deer food, but not quite. He stoops and



FIG. 114. Onk likes the taste of the roasted deer meat

touches the dead deer again and sucks his fingers. It is not bad, that new taste! The Fire Beast had done something good to that deer!

Again and again Onk tries it, liking the taste better and better each time. He draws the deer out in the grass away from the ashes. A leg comes off quite easily as he does so. That's queer! Generally he has to tug and pull hard to break off a deer leg. The bone snaps easily in his powerful hand. He feels the flesh in his mouth. How soft it is! How easy to bite! He eats more and more, until nearly half the deer is gone.

Now Onk runs through the forest, grunting the news of the new food to his family. They run back with him, and he shows them how he has eaten the meat. They too begin to tear the flesh from the bones, and in a few minutes these Dawn People have eaten all the roasted deer. Then they crack the bones open and suck out the marrow inside them.

The Fire Must Not Go Out!

Can you imagine what an event this discovery of cooked food was in the life of the Dawn Men? Today we think that it was one of the great accidental discoveries of all time. Of course, as we said, we cannot even guess at all surely when it happened or where. Perhaps time and time again many nature peoples had the same experience throughout the first million years. Perhaps one bright man (or woman) among these Dawn Men began to understand; he told others, and they told others, and the idea spread from family to family over large regions and finally to all the continents.

We do know that by 25,000 years or so ago the peoples of the earth had learned that if they gave the Fire Beast more logs to eat he would stay with them. By some strange power logs would also keep their own little Fire Beast alive. Now the fire could warm their caves or huts in cold weather, give them light to see by in the dark nights, keep the forest animals away from them, and cook their food.

Can you not imagine a Dawn Man leaving his wife and children in the morning to hunt for food and saying before he went: "Give the Fire Beast enough to eat, or he will go away. Then we shall have to wait until another Fire Beast comes again!"

"Don't let the fire go out!" might well have been the watchword of those times.

But, in spite of warnings and spankings which the Dawn Man must have given to his children when they

forgot, fires did go out! Then what a long wait they would sometimes have! For although the Great Animal was often angry and sent his fire beasts streaking through the sky, he did not always strike the trees or bushes. Then how these people, who knew what it was to have fire, suffered! And how they struggled to find another fire, for you see they had not yet learned how to make one.

At Last Man Learns How To Make Fire

We can only guess that it was perhaps through an accident that people learned that fire could be made.

Perhaps one day a Dawn Man was lying on the ground, looking up at some tall trees swaying and rubbing against each other in the wind. Back and forth they went, those tall old trees. The bark was very dry. Now and then the man could see a bit of bark dust falling to the ground.

Suddenly, however, he noticed something else. Was that smoke? Smoke it was, coming from the trees! He got up and went closer. There was more smoke as the bark of two old trees rubbed together. For a long time he looked for the Fire Beast, for surely there could be no smoke without fire. There it was, a tiny spark beast; it had fallen on some dry leaves near by. The wind was blowing it. Quickly the Spark Beast was becoming larger and larger; now it was a real Flame Beast.

"How strange!" thought this man as he watched the beast spread. Here was fire that had been made



FIG. 115. The Fire Beast warmed the caves of early men

without the Fire Beast himself striking down from the sky. Long he watched and thought. Perhaps not that day nor even the next did he get his great idea. But sooner or later, he did! He could make a fire beast! He would rub dry pieces of wood together!

Quickly this Dawn Man got two soft, dry sticks. He rubbed them back and forth quickly. At first nothing happened. He looked very closely, but there was no smoke. Then he rubbed faster and faster. Ah! the sticks felt warmer. Still harder he rubbed. Dry bark dust had now collected, and he threw some dry leaves around it.

After almost half an hour of rubbing and rubbing, he nearly shouted with excitement. Little curls of

smoke were beginning to rise from the dust and leaves. He breathed on them gently, just as the wind had done to the fire beasts. "Hurrah!" — or whatever grunt meant that to this bright man — "I've done it!"

A little spark had caught in the bark dust and leaves. Then another and still another! Suddenly — a flame. The dry things caught fire. The Dawn Man had done it! Fire had been made at last!

How Nature Peoples Tell of the Discovery of Fire

Our story of fire is one way of imagining how it might have happened. Of course the nature peoples themselves had many other stories which they told to their children and grandchildren through all the ages. We have space for only a few; but these will show that perhaps for thousands of years people have tried to explain how man learned about fire.

The Maoris of Australia say that the god Maui got fire from the toenail of his grandmother. When he pulled out the nail, it started a fire in heaven. Even Maui and his grandmother caught on fire. But just in time heaven sent a rainstorm to put out the fire. Only a piece which Maui's grandmother threw down onto the earth remained. This caught in a tree and kept burning. It is from there that we men of the earth still take it, say the Maoris.

Certain North American Indians sing of the great buffalo that came racing down from the sky. His hoofs struck against the rocks and made sparks. The sparks set grass on fire, and people have had fire ever since.



FIG. 116. The North American Indians thought the Fire Beast was a buffalo

Away off in India the Hindus of long ago imagined much the same kind of happening. They thought that great horses in the sun made the lightning by striking sparks from their hoofs on the hard floor of the sky. The early people of Peru told how a god threw stones through heaven with his giant slingshot, causing thunder and lightning. To the Tatars of central Asia there was a god, Judai, who knew the secret of how to strike stone on iron and make fire. Among the Finns, poems tell how fire was the child of the sun and came down from heaven.

How Nature Peoples Make Fire Today

Scientists think that the kind of story which we have told of Dawn Men and fire is more nearly the correct one because it is the way that tribes of nature peoples make fire today. They use friction; that is,

they rub things or strike things together to give heat or sparks. In figure 117 we can see four of these ways. *A* shows a woman of a North American Indian tribe holding a stick with a string wound round it. As she whirls the stick rapidly, its point bores into the dry stick below it, making it hotter and hotter. Soon a spark flies and sets fire to the wood. It is said that these Indians start a fire in this way in 30 seconds.

B shows an Indian brave who has a different way of whirling the stick. He pumps the bow up and down. The string works just as that of the woman did. *C* shows two natives of the Malabar Coast of India starting a fire by sawing two sticks across one another; and *D* shows an Australian native using the Indian method, only he twirls the stick with his hands.

Other nature men found out that they could start a fire almost at once by striking a flint against a certain kind of iron and rock. With just the proper blow sparks would fly (figure 118). By having a little pile of dry bark and leaves under it, one could — if he was clever — throw the sparks into the dry material and start a fire. That was such a quick way that, once it had been used, most people learned it, and the idea spread all over the world. For thousands of years the flint was used, even to the time of the settlers in the wilderness of North America. Indeed, in the days of 1820, 1850, and even of 1870, fires were started in this way among the pioneers.


A. Whirling a stick with a string


B. Using a pump drill


C. Sawing two sticks across one another


D. Twirling by hand

Fig. 117. Four simple ways of making fire



FIG. 118. Nature men discover that fire can be made with flint

Throughout History All Peoples Carefully Watched Their Fires

Is it any wonder that every people on the earth learned to guard their fires carefully? Many of them selected special persons to do this. Among some North American tribes of Indians certain women always carried a blazing fire stick as the tribes moved from one place to another. Never would they let the fire go out.

It was around the fire, too, that people always met for their councils, just as in our houses today we light a fire in the fireplace and pull chairs up round it, even if we have an oil heater in the basement that can be started just by turning a button! The fire draws us around it and holds us to it.

To many of the early people fire became sacred. The Egyptians of several thousand years ago had a fire in every temple. This was cared for by a special officer.

Three thousand years ago the Greeks, as well as the Persians of western Asia, kept such a fire going in every village. When the Greeks sent armies to war they always carried an altar of fire with them, and torches lighted at the community fire.

Among the Romans of 2000 years ago women called the Vestal Virgins were given the honor of watching and caring for the fire on a sacred spot close beside the community fountain. Around this spot grew up not only the gossiping place but the town hall, where matters of government were discussed and settled. If, by some strange chance, the sacred fire was allowed to go out, all public and private business in Rome stopped instantly! "The gods are angry," said the Romans. If the heavens did not storm and rage and send down a bolt of lightning for a new fire, the Roman priests rubbed the two sacred sticks of the temple together and started a new fire.

"Very interesting!" perhaps you are saying; "but what has this story of fire to do with metals and tools?"

Ah, that is very important; for until men had learned to use fire, they could not work with metals. Let us go on with our story, then, and see how men could leave the Stone Age and learn to use the metals that were lying everywhere on the earth.

Books You Would Like To Read

See the list given at the end of Chapter XIV.

CHAPTER XIV

Metal Tools Made in Fire

Long Ago Men Knew There Were Metals in Rocks

NO DOUBT the people of the Stone Age had found metals from time to time as they walked through the forests or open spaces. Now and then they would come across rocks with shiny spots in them. These might be of a greenish or bluish color or a yellow or black one, or they might have a grayish tinge. We know today, of course, that these rocks were different kinds of "ore."

The green-blue ore contained copper; the yellow ore contained gold; the black ore contained tin; and the others contained either silver, lead, or zinc. Of course the nature peoples of long ago did not know about these metals.

Which people were the first to try to make use of these ores we cannot be sure; but we do know that on several continents the people had tools of copper. How these early copper tools were made we do not know. Perhaps at first men just pounded lumps of free copper into the shapes they wanted. They found that they could shape chisels and other simple tools out of the lumps with their stone hammers; and they did, just as the North American Indians are doing in the picture of figure 119.



uthsonian Institution

FIG. 119. North American Indians hammering tools out of copper

Another Discovery about Metals

Perhaps the next new idea to be discovered was that metals could be melted out of rocks by heating the rocks in fires. Who did it we do not know. It might have been an accident, like so many other discoveries. But certainly ancient metalworkers must have found that if they smashed a chunk of ore into bits and heated it in a very hot fire, the copper would melt and run out by itself. For thousands of years the early peoples had built wood fires around piles of stones just as any Boy Scout knows how to do today. Very likely

some of these stones held bits of copper within them. We can imagine that many, many times the copper in the rocks melted and ran out in a kind of reddish lump in the bottom of the fire. No doubt this happened many times before some bright man noticed it. Perhaps thousands of years passed before just the right man — that is, a toolmaker — observed it.

Let us imagine what might happen when at last some man interested in tools does notice such a lump of metal in the ashes of his fire. He examines it closely.

"That's strange," he thinks. "What kind of stone is that? It looks like that greenish rock I pounded into an axhead last year."

While the metal is still hot, he pounds it with a hammer. It can be shaped easily. Within a short time — indeed, in much less time than with the pieces of cold metal he had pounded before — he has made an axhead out of it.

Now he goes about searching for more of the greenish-colored rock. Not far away he finds some and brings it back to his fire. He throws it in and it begins to get warm, but — nothing happens! Again and again he tries, and always the rock remains as whole and solid as before.

Learning To Make Hotter Fires

1. *By Burning Charcoal*

Our toolmaker tried many things before he found the trouble. What was wrong? *The fire was not hot enough!* What should he do to make the fire hotter?

Ah! he had an idea. He would blow on it! blow under it to fan the flames. He blew and blew, but neither blowing with his breath nor fanning with an animal skin softened the rock. Perhaps he thought and experimented for a long time. Perhaps he failed completely and gave it up for the rest of his life. If he did this, other toolmakers discovered the secret long afterward.

However it may have happened, some toolmakers of long ago did find out how to make a fire hot enough to melt ores. We can imagine that there were two steps. First, they found a better fuel. They had been burning the logs of the forest around them. Then a fire-maker discovered, perhaps also by accident, that wood that had been "charred" — burned a little — made a hotter fire than the fresh logs. So they invented a way to char the wood. They piled many logs in a high mound, threw earth over it, and let it burn slowly. Before the wood was burned completely the covering of earth was taken off. The logs had become hard, blackened pieces of wood. We say today they are charred, and we call such burned wood "charcoal."

Gradually charcoal came to be used instead of logs to make the fire to melt iron and other ores. For thousands of years it was the best fuel that the metalworkers had. Even down to the time of our grandfathers in America it was used. In fact, it is still burned today by blacksmiths in little towns to give a hot fire in their hand forges.

2. *By Inventing the Bellows*

The next step was to find a way to blow a stronger "draft" of air through the fire. How many experiments the early "smiths" (metalmakers) carried on to find that out we have no idea, for there are no traces today of the bellows used thousands of years ago; but we can be sure that inventors among all those ancient toolmakers did succeed in doing it. Today nature peoples in different parts of the earth use bellows to blow strong drafts through their fires. Figure 121 shows an interesting bellows used by one tribe.

In some such way as this, with charcoal and with a bellows to give a good draft of air, we think the later Stone Age peoples of 10,000 years ago must have found out how to melt copper and other metals out of ores. Today, as you know, we call this work "smelting" ore.

Tools of metal now began to take the place of tools of stone. Not only copper, but tin, lead, zinc, gold, and silver were used by these early peoples. We know this because things made of these metals have been found in their graves.

Of course these changes did not happen suddenly. Very likely several thousand years passed while a few toolmakers were giving up stone and learning to smelt the metals out of ores. In some parts of the earth stone is still used, even to the present day; but sooner or later, among most peoples, metal took its place.

The New Copper Tools Were Not Entirely Satisfactory

These metal tools, however, were not satisfactory in one way. They were fairly soft, and so did not make very good tools. A few good whacks of a copper hammer on a block of stone, and the head was all out of shape. Knives and axes and saws of copper had to be sharpened every little while; even for cutting logs these tools did not stay sharp very long.

We can imagine that complaints began to come to the toolmakers: "Our new axes are too soft. A few blows, and the edge is all gone. Give us the good old stone ax. It's blunt, but it lasts."

Probably the toolmakers themselves had known that and had been worrying about how to make the tools harder. We can see them trying different experiments. Finally one tries something that works! Perhaps, again by accident, he puts the new tool that he has just been making back into the hot fire; then he removes it and hammers it again; he puts it in again and hammers it again. Several times he repeats the heating and hammering. He tries the edge. It is harder! Again he tries another piece of copper, heating and hammering. Each time the experiment is more successful; the ax edge or knife edge is somewhat harder. It can be used to cut logs or stone a little longer without becoming dull.

When the day came that an ancient toolmaker learned to do that, a new way of working with metals had been discovered. Today we have a name for such heating and hammering of metal. We call it "temper-

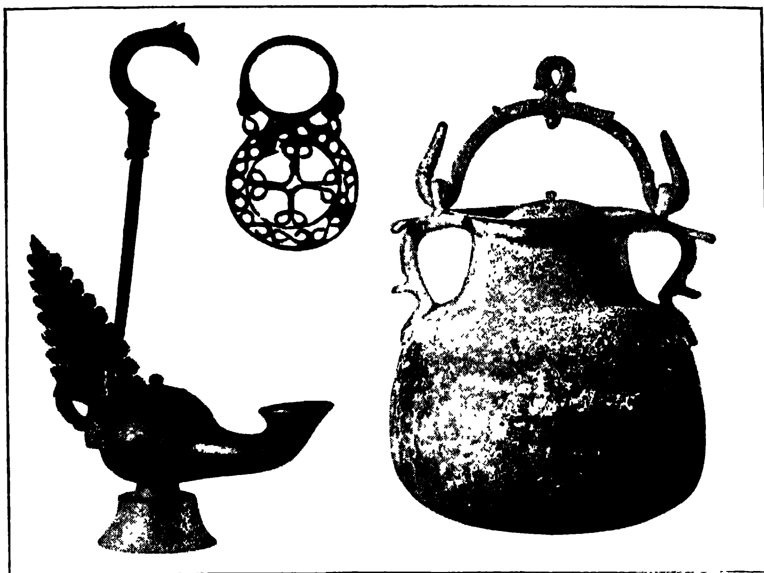
ing." But even "tempering" did not make the copper hard enough. Those who were used to the hard stone tools probably continued to find fault with these new tools.

The Most Important Invention of All: Mixing Metals

The later Stone Age inventors went right on trying new things, studying and watching what happened. Then they stumbled onto another new idea. We say "stumbled" onto it, because another accident might have helped. Perhaps a very intelligent toolmaker noticed that when he melted ore that came from a certain place it was a harder metal than when the ore came from another place. Why was that?

He tested the ore and noticed that it was not made up of one metal but of several different metals mixed together. Of course no one at that time knew anything about how to separate these metals from one another. Many years must have passed before people learned how to do this; but one day a toolmaker did find a way to smelt the ore in a very hot fire and separate the copper from the tin, the lead, the zinc, and other metals which were there.

But, finally, one or more of the metalworkers got just the right mixture of copper and tin to make a very hard metal. He poured nine measures of melted copper and one measure of tin into a vessel. Then he heated the mixture in a very hot fire and let it harden. After it had hardened, he heated the lump of metal in a forge and hammered it into a tool.



Museum of Fine Arts, Boston

FIG. 120. These are things that men made of bronze long, long ago: a lamp, an earring, and a covered bucket

He tried cutting something with it. Wonderful! What an edge it had! It would cut the hardest logs without becoming dull on the edge, as the copper tools did. And how much sharper it could be ground!

Then the toolmaker tempered the new tool, heating it in the forge and hammering it again and again. Ah! it was still harder. A chisel made of the new mixture chipped stones for a long time; a knife or a scraper or a sword cut better and stayed sharper than any tool that had been made before.

We have a name for such a mixture of metals today; we call it an *alloy*. And the name of that new mixture

of copper and tin which the toolmakers learned to make is *bronze*. Bronze was, perhaps, the very first alloy. Ever since that day, right up to our own time, engineers and scientists have been trying to make new alloys. As we read more of the story we shall see them mixing all kinds of metals in the attempt to make stronger or harder or tougher metals for engines and machines and tools. This making of bronze was, perhaps, one of the very greatest inventions in the history of metals.

The Bronze Peoples Lived in Settled "Civilizations"

Our scientists sometimes speak of the peoples who used bronze as "the bronze peoples," and they call the time when they lived "the Bronze Age." Although they are not absolutely sure which of the ancient peoples were the first to make things of bronze, many of them agree that it was the Egyptians. They prove this from the tools and weapons which have been found in the tombs of Egyptian kings. These show that about 6000 years ago (that is, 4000 B.C.) fine things were being made of bronze.

We find too that the ways of living of such bronze peoples as the Egyptians had changed much from those of the Stone Age peoples. They had learned to plant seeds and cultivate crops; that is, they were farmers. They built permanent houses and other buildings, not only of wood and mud but also of stones and bricks. Some of them lived in towns and even in large cities with paved streets and tall buildings. Large reservoirs

outside their towns stored water which was brought to their homes through lead pipes as well as through pipes of wood. Other pipes took away the sewage from the houses.

Think back a moment to the story of the building of the Great Pyramid for a good example of the tools of 6000 years ago. Our scientists have found bronze saws, chisels, and other tools whose edges are sharp even today. Some have jewels set in them, making the edges still sharper. Our best toolmakers today cannot discover how those 6000-year-old Egyptian tools were made. The art of the Egyptians was lost when they passed away, and, so far as we can learn, no books were written to tell how it was done. It was one of their secret and mysterious ways of working.

But the invention of ways to smelt and mix metals brought some unpleasant things as well as good things to peoples of this world. It brought bigger wars! People could now have better swords and spears and war axes and knives and daggers of bronze instead of stone. They could make shields, battle-axes and war helmets, vests and breastplates, of metal that no arrows or even spears could pierce.

Perhaps the greatest war machine that metals and tools gave to people was the chariot, a two-wheeled vehicle usually drawn by two horses. This was covered with bronze plates and had long, sharp knives of bronze sticking out from its sides. How terrifying a troop of horses and chariots must have been to the people who were used to fighting on foot

with bows and arrows and axes and spears and knives! It would be like a fleet of steel tanks mowing down people and buildings today!

Does life in the Bronze Age sound very much more "advanced" than life in the Stone Age? It does, indeed. A new day had dawned in man's history, and the art of smelting metals helped as much to bring it about as did any other thing.

Books You Would Like To Read

EVANS, WAINWRIGHT. The Thunder Bird, the Story of Fire. Thomas Nelson & Sons, New York.

HAWTHORNE, NATHANIEL. Mosses from an Old Manse. Houghton Mifflin Company, Boston. Wayside Edition.

HIBBEN, THOMAS. The Carpenter's Tool Chest. J. B. Lippincott Company. Fascinating information about the contents of the carpenter's tool chest. All the tools the carpenter has used down the ages and still uses today.

HOUGH, WALTER. The Story of Fire. Doubleday, Doran & Company, Inc., Garden City, New York. The story of fire from early times.

LANSING, M. F. Great Moments in Science. Doubleday, Doran & Company, Inc., Garden City, New York. Interesting information about such subjects as fire, light, water power. A timetable of great moments in science.

MEREDITH, CLIFF. Fire! Reynal & Hitchcock, Inc., New York. The history of fire, telling how man has learned to fight fires throughout the ages.

KUMMER, F. A. The First Days of Knowledge. Doubleday, Doran & Company, Inc., Garden City, New York. Man learning to make tools and metals; harnessing the forces of nature for his needs.

PLIMPTON, EDNA. Your Workshop. The Macmillan Company, New York. Things to make and do with tools.

CHAPTER XV

New Metals : The Age of Iron and Steel

BUT NOT for long was bronze the king of the metals. Soon — oh, after a few thousand years — another metal was to be discovered which would take its place. That metal was *iron.* Although the peoples of long ago did not know it, with iron were to come new alloys which would change the world in ways that men had not dreamed of before.

To get a picture of how iron might have been smelted in the early days of its discovery, let us go to some nature peoples who are living on the earth today. Although they live in the same world as ours, their ways of mining and making iron are really those of the early Iron Age people of long ago.

Ten Pounds of Iron a Day in Nigeria

Shut your eyes and imagine yourself in a village of beehive huts in Nigeria, on the west coast of Africa. Just outside the village we come upon two Negro iron-makers squatting beside a deep hole in the ground. One of them has started a roaring fire in the bottom of the hole and is now laying pieces of charcoal crosswise over the hot coals. Over the charcoal he puts chunks of red-colored rock which is piled up beside him.

"That rock is the iron ore which we saw being

dragged on logs from the hills yesterday," we think to ourselves. "All day long those men dug and smashed the rocks with their hammers. Now they are going to smelt it."

On the layer of ore they place another of charcoal, crosswise again so as to leave spaces for drafts of air. Next come more logs and then more ore. Finally the hole is full and the fire is burning brightly.

But now what is that man doing with those tubes of bamboo, which pass through two blown-up things of animal skin (figure 121)? He is pumping air into the fire with a simple kind of bellows. He pumps on the bellows and — sure enough! — a sharp blast of air can be heard coming up through the fire.

All day long the men sit by the charcoal fire, working the bellows and adding charcoal and ore and stirring them together. At dusk the fire burns low. Then the natives dig down into the hole with some iron tongs and lift out a lump of hot metal.

From their whole day's work the two men have made about ten pounds of iron. Not much like a huge steel corporation's blast furnace today, which makes over a million pounds of pig iron in a day with just a few men! What a difference between the simple way of nature man and the engineering way of modern man! How did modern man ever learn how to do it?

[1] A drawing based on a sketch by Richard Buchta, from Ratzel's *The History of Mankind*, by permission of Macmillan & Company, Ltd.

[2] From J. Russell Smith's *The Story of Iron and Steel*, by permission of D. Appleton-Century Company.



FIG. 121. Blacksmiths make ten pounds of iron a day in Nigeria[1]



FIG. 122. The Catalan forge of Spain was the model used by many countries for hundreds of years. Do you see the bellows?[2]

When Was Iron First Used?

To answer that question let us go back to the early days of the Iron Age. How far must we go? We do not know exactly.

We know that some of the bronze peoples of 5000 years ago were also using iron, perhaps smelting their ore in somewhat the same way as the two African natives. Pieces of man-made iron have been found in some of the Egyptian pyramids and tombs built earlier than 3000 B.C. Well-made iron tools have been found in Mesopotamia, where Assyria stood nearly 5000 years ago. We are certain that the Etruscans who lived in Italy in 100 B.C. were making iron. But they had come to Italy from Asia Minor, bringing their knowledge with them, so the first ironmakers among them must have lived much earlier than 3000 years ago. It is now believed that the Egyptians learned the art of ironmaking either from the peoples of Asia Minor or from the darker-skinned natives of Africa. Some scientists think that iron had been worked among the African tribes for a very long time before that.

Among the Greeks of the 800's B.C. the use of iron must have been common, for their great poet, Homer, mentioned it in some of his poems. In one place he speaks of the hero, Ulysses, plunging a stick into another man's eye just "as a blacksmith would" when he thrust a piece of iron into water. Homer could not have used such an example in his poem if iron had not been widely used at the time.



Ford Motor Company

FIG. 123. Making iron in India long ago. The man at the left is using his lungs as the bellows to keep a draft of air under the fire

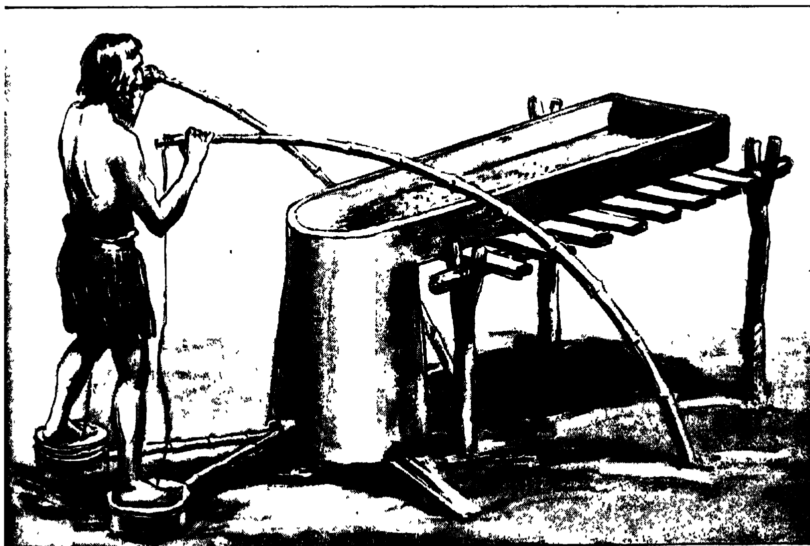


FIG. 124. Do you see how the bellows works in this blast furnace?

You can see, therefore, that the people of the Mediterranean region were not only making things of bronze; they also knew how to smelt iron and shape it into tools and utensils and weapons.

What about India and the Far East? Did those people have an Iron Age? We know that ancient India had some of the best iron deposits known at the time. There was no tin, so the people could not mix copper and tin to make things of bronze. But their books speak of iron being used. Some people say these books were written in 1400 B.C., but others think it was as early as 3000 B.C.

As for China, there is proof that iron was used there about 700 B.C. — 2600 years ago. But we can feel sure that the early Chinese must have used it long before that time.

So the scientists cannot tell exactly who invented iron smelting and who copied it, but they can tell that it was being used several thousand years ago.

The Bronze Age Slowly Passed into the Iron Age

The centuries passed, while over the three continents — Europe, Africa, and Asia — people began to use iron for tools and weapons that had to be sharp and strong.

But in all the thousands of years, down to our own times, there was only one real improvement in iron-making. That was the building of the Catalan forges. These forges were named from the region Catalonia, which is in the Pyrenees Mountains in Spain. There the toolmakers invented better forges than had ever

been made before. First they built up stones or bricks and burned charcoal inside them; then they made a bellows to give a stronger blast of air.

Figure 122 shows a Catalan forge. Forges like this were built in our own state of Pennsylvania as recently as 1800. At the bottom charcoal was burned. Above the charcoal were layers of iron ore. A heavy bellows blew air through the fire. When the iron melted, it ran to the bottom in a pasty lump. Then it was drawn out through a hole and hammered into shape over an anvil. "Not much improvement on the Hindus or Etruscans of 3000 years ago!" perhaps you think. Not much; and yet several men running a Catalan forge could produce 2000 pounds (one ton) of pig iron in a day, 200 times as much as the two African Negroes of our story!

That is the story of ironmaking until the 1500's A.D. — only 400 years ago. After that time other improvements were to come and many changes were to take place.

Better Fuel To Make Hotter Fires

In the 1500's more and more people began to call for iron goods, and more and more furnaces were built. Woodcutters went about everywhere cutting down trees to make charcoal for fuel. As this happened many people in England began to fear that their forests would be destroyed, and in 1558 Queen Elizabeth forbade the cutting of timber for ironmaking in certain regions. In 1584 she forbade the building of more iron furnaces.

There was, of course, a good deal of grumbling at this, not only from the business men, who wanted to make and sell iron for profit, but from the people generally. Even a queen could not stop people from wanting a thing that was as much needed as was iron.

But the ironmakers did admit that they must have a new fuel. What should it be? Some people said, "Try burning soft coal." Soft coal had been known for hundreds of years, and England had much of it. It was on the surface of the earth in the hills and fields of many parts of the country.

"Very well," said a few of the ironmakers; "we will try coal." And they did.

Enter "King Coal"

The Greeks and Romans had also known coal 2000 years before. Theophrastus, a Greek who lived about 300 B.C., wrote a book in which he spoke of "brittle stones . . . which become . . . burning coals when put into a fire." No doubt the Greeks burned coal before this time. Some students say the Chinese did before that, but we cannot be sure. The Romans had burned it while they were in Britain (2000 years ago), but not much is heard about it until about 1200 A.D. From then on, until the 1500's, coal was used. But people had a hard time to make it burn. It was as the Greek had said, a "hard and brittle stone," and making fire with it was not easy. Nevertheless some people kept on trying, and miners did continue to dig it from open pits in the ground with their pickaxes and shovels.

After the 1500's when good Queen Bess commanded the people not to cut down any more trees, there came a much greater demand for coal. So more and more inventors tried to find ways of making the "brittle stone" burn.

The Story of "Dud" Dudley

One of England's cleverest and bravest inventors was the son of Lord Dudley, who owned some iron mines. After leaving Oxford University this son, nicknamed "Dud," was put in charge of one of his father's iron furnaces. "Dud" soon found that the wood in the region was all used up and that the furnaces were standing still. No fuel! "Let's try coal," said Dud, and he set to work. At first his experiments were not successful, for the sulphur and other impure things in the coal mixed with the iron and spoiled it.

Dud went on trying, and after many disappointments he invented a way of burning coal that drove the sulphur and other things out and left a gray-black "hard rock." So far as we know, this was the first making of coke.

Next Dud piled up a furnace full of iron ore and coke as he had done before with iron ore and charcoal. Then he started his fire. The bellows pumped air into it, and the fire burned. Hotter and hotter it became — hotter than any charcoal fire Dud had ever made before. When the iron was ready, he took it out and hammered it. Next he tested it, and then he sent it away to London and asked the experts to test it. They

sent back word that it was better than the iron that was being made in any other place. The new fuel was a success!

Soon afterward Dud wrote to his father telling him that, with the coke, he could make three tons of excellent iron a week in his furnace. In 1620 the English government gave him a "patent" on the new way of turning coal into coke. This meant that during the next fourteen years he and he alone could use this coke-burning method.

Dud and his father started more furnaces in other places and seemed on the way to becoming rich, when enemies began to oppose them. These enemies were, first, other ironmakers who were eager to have the business which the Dudleys were getting; second, the charcoal-makers, who were making money by selling charcoal to the ironmakers. They saw that if coal came into use they could not sell their charcoal.

"But," perhaps you say, "why could they not go into the coke business too and sell that instead of charcoal?" They could, and later some of them did. But at first most of them did all they could to destroy the new furnaces. Mobs of workmen were paid to go to the coke ovens and smash the bellows and the furnaces. They aroused people against young Dudley, and he was driven out.

During the rest of "Dud's" life he was in trouble. War came, and he was thrown into prison. From there he escaped; but he was shot and wounded, caught, and put back into prison again. When he was finally



FIG. 125. Angry workmen destroyed Dudley's ovens and bellows and furnaces so that he could not use coke to make iron

allowed to go, he wandered from place to place. At the age of eighty-five he died — an unhappy man. But he would not tell how he had made his coke and used it to smelt iron, and his secret died with him. Meanwhile other men tried, but for nearly 100 years after Dudley no one really succeeded. Not until the 1700's did they learn again how to make coke and to use it for the hottest fires yet known.

In the 1700's Came a Still Greater Need for Good Iron

As you know, the 1700's were the years when the first steam engines and the spinning and weaving machines were invented. By 1700 Savery and Newcomen had built their pumping engines, and these were being used in the iron mines. Then came Watt and the building of the first real steam engines. It was about the same time that James Hargreaves invented the spinning jenny and Arkwright and Cartwright their textile machines. For all of these iron was being used.

Meanwhile other thinking men were finding new uses for iron. In 1779 Abraham Darby designed and made an iron bridge to go over a small river. The town was named "Ironbridge" in honor of the bridge, and in 1788 the Society of Arts gave Darby a gold medal. Soon other places wanted iron bridges. Watt also wanted more and better iron for his engines, and the textile men better and more iron for their machines. Inventors were trying to make locomotives and to run them on iron rails. So all these people cried: "Give us

better iron. Give us harder iron. Give us iron for sharp tools. Give us iron to hold up heavy loads. Give us iron to push and pull and pound." And they wanted it in quantities such as the Egyptians and Greeks and Romans and Chinese could never have dreamed of.

Special Kinds of Iron

1. *Cast Iron*

Although these people were calling for "iron," what they really wanted was special kinds of iron. Even then, 200 years ago, they knew that there were several kinds and that each could be used to do work. Let us see what some of them are.

First, there was "cast" iron. That was really another name for the pig iron as it came from the furnace. Cast iron is very brittle. If you pound a thin piece of it, it will probably break.

Cast iron is used for many small things. Look around you in your schoolroom. No doubt the brackets that hold up the desks and shelves are of cast iron. Go into any hardware store or even a 5-and-10-cent store. Many of the simple objects for sale are "cast" (poured in a mold) from pig iron. But, of course, nothing that has to bear a heavy load can be made of cast iron.

That is what the ironmakers of the late 1700's were discovering. Cast iron would do for water pipes or sewer pipes which could be laid deep in the ground, but it was not strong enough for engine boilers or bridges. Boilers were exploding and killing people.

Bridges were breaking down. "Give us tough iron that will hold steam under great pressure," said the engine-builders. "Give us a strong iron which can be made to reach across a river and hold up wagons and people," said the bridgebuilders.

2. *Inventors Produce Wrought Iron*

So, with much head-scratching as well as hard thinking, the inventors went to work at the problem. They knew what was wrong. There were impurities in the cast iron, and some way must be found to take them out.

Some inventors tried what ironmakers had been attempting for thousands of years — to make the fire hotter! "Make it so hot that the ore will boil," they said. "Boiling will mix it well and take out the impurities." But boiling did not seem to solve the problem. The iron was still too brittle; things made of it broke easily.

Other inventors thought that stronger bellows would make better iron. With these they could blow more powerful drafts of air through the fires. So machines were invented by which water wheels moved the bellows. Horses were also used to supply the blower with power.

After 1765, as you know, James Watt's engine was a success. Here was an idea! Fasten an engine to the bellows! In 1776 (a famous year for Americans too) an English ironmaster, John Wilkinson, succeeded in doing it. What a blast of air that mechanical power

blew through his iron furnace, and without human or animal muscles, too!

Meanwhile more inventors were trying to find still other ways to make tougher and stronger iron by getting rid of the impurities in pig iron. Each of the things done so far had helped a little; but ironworkers were still hammering red-hot lumps of iron, heating them again, then hammering and heating time after time. It was slow business indeed!

In the year 1783 two Englishmen, Peter Onions and Henry Cort, made an experiment. They put pig iron in a furnace and stuffed all the cracks in the furnace with clay. Then, with the aid of a steam engine blowing terrific blasts of air, they made a very hot fire. Hotter and hotter it became. The pig iron melted. It boiled. Onions said that "it thickened into a kind of froth."

As the "boiling" went on, Cort had the workmen open the door, stir the hot mass, and close the door. Then they gave it a larger blast of air, opened the door, stirred it some more, and again closed the door. Again and again they repeated the melting and stirring, melting and stirring. Then they took the hot mass of iron out and tested it. It was much less brittle than pig iron or cast iron and much tougher. They had really rid the metal of the impurities; here was good "wrought" iron!

Cort's wrought iron came out of the furnace as tough as the wrought iron that had been many times hammered and heated, hammered and heated. Because he had improved on the ideas of Onions and all

the others who had tried this way before, the method is named for him. It is called the Cort "puddling" method. Because of his puddling scheme Cort became one of the most famous ironworkers of that time. He turned out just what the engine and machine-makers and the bridgebuilders wanted -- more iron, cheaper iron, and tougher iron.

That was in the 1780's. For the time being, the engine-makers and machine-builders were satisfied.

The Dawn of a New Age

The years 1800, 1810. 1820, 1830, 1840, came and went. During that time Watt engines were being built in many cities of England, France, America, and other countries. Hargreaves and Arkwright and others in England were making spinning and weaving machines; and, in New England, Slater and Lowell and others were building cotton mills. Restless Americans were crossing the Appalachians and beginning to settle in the West. Manufacturing cities and towns were springing up in the new United States as well as in the older European countries. Along the Atlantic plain of America, as well as in England and France, inventors were experimenting with the new railroads.

For all these new industries still stronger materials were needed. "Wrought iron is not enough," said the business men. "Give us a metal as hard as the fine old swords of Damascus that will bend double and not break!" The swordmakers of Damascus, in Asia Minor,

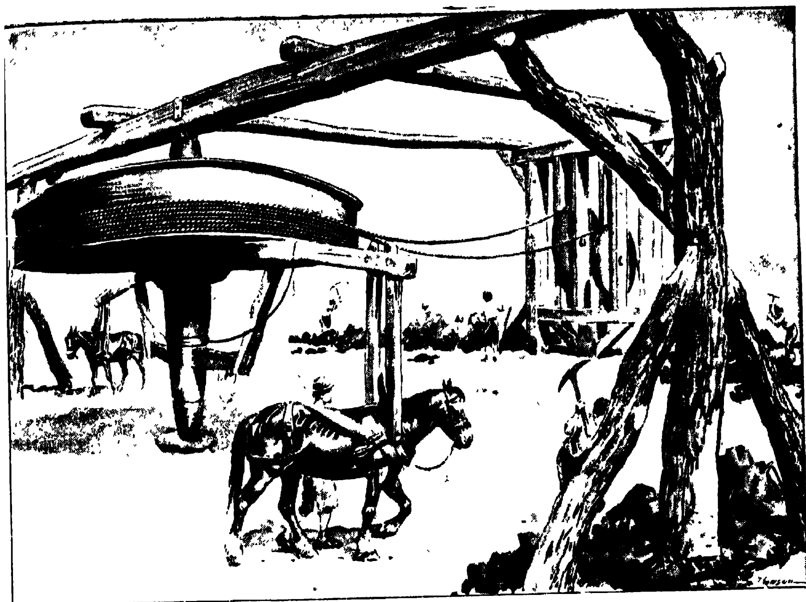


Fig. 126. How coal was drawn from the early British mines by horse power



Lukens Steel Company, Coatesville, Pa.

Fig. 127. Inside an American iron-rolling mill of 1820

had been famous 2000 years earlier for the wonderful hardness of the metal that they had learned to make.

Let us not forget that most ores are really alloys. Copper is generally not pure copper. It has lead or zinc or tin or other elements mixed with it. You saw that that was true when men discovered how to make bronze.

The same was true of iron. Out of the crude furnaces of long ago came all kinds of mixtures. One lump would contain iron and one set of mixtures; another had a different set. It was like recipes for cakes, with different amounts of flour, sugar, and the like for different kinds of cakes. In this case the elements which went into the mixture were iron and carbon, manganese, silicon, and phosphorus.

Of course the ironmakers of long ago did not know of these things. They only knew that if they dug the ore from a special place, hammered and heated it, and then put it suddenly into a tub of cold water, it became very hard. Then, by heating and hammering and plunging the hot iron into cold water time and time again, they could make a harder metal than any metal known up to that time.

In Damascus 2000 years before, and later in Toledo, Spain, skilled metalmakers had discovered these tricks and kept them as secrets. "Get your ore from that particular mountain!" whispered they to their sons. "It contains just the right things. Hammer it just so and so. Heat it just so long, hammer it so many times, and put it into the water so and so and so." Thus the

secrets were passed on from father to son for hundreds of years.

These famous metalworkers were really making "steel" — steel knives and steel swords and other things. And although they did not know it, it was all because nature was supplying them with natural alloys — just the right mixture of metals. The ores that they found in one place might contain tungsten mixed with iron. Our metalmakers of today know that this mixture makes the hardest kind of steel. In another place the iron might be mixed with manganese. That would make good steel too, but it was not quite the same as tungsten steel. There were still other mixtures and still other kinds of steel.

Now, the engine-builders and the machine-builders of the early 1800's did not know any more about these things than did the ancient peoples. The ironmakers did not know about them, either. They only knew that there must be ways of making harder metals. So experiments were always being made.

Kelly and Bessemer Discover How To Blow Air through Iron

We have already told the story of how William Kelly in America and Henry Bessemer in England discovered the cheap and quick way to make steel out of heated pig iron. "Blowing air through it will do it," shouted Kelly, the Kentucky kettle-maker, as he jumped to his feet with the first flash of the idea.[1] That was in 1846.

[1] You know the story from Chapter XXII of *The Building of America.*

"Blow air through it," said Bessemer seven years later.

Both men had succeeded. They had sent big blasts of air through the mass of frothy boiling metal! Sparks flew in all directions!

"Fireworks!" exclaimed some of Kelly's neighbors. "Might as well try to burn ice," said others as they sneered and laughed.

But, strangely enough, the "fireworks" did the trick! When the air had passed through and the metal was cooled quickly by being plunged into cold water, it was steel! Not pig iron, nor cast iron, nor wrought iron, but steel — with just enough carbon in it to make it very hard and very tough. Here, at last, was steel for bridges, steel for engines and machines, steel for rails, steel for all the things that men wished to make.

Science Improved Steelmaking

We must not think that all these things came at once. It took many years of hard study and experiment by many inventors before ways of making them were found.

As the years passed — the 1860's, 1870's, 1880's, 1890's, and 1900's — many improvements came. The steel companies employed men to do nothing but invent better ways of doing things. Engineering schools carried on experiments and taught young scientists and engineers how to experiment with metals. The United States government and the governments of the states helped too.

Steadily, step by step, every part of the work of steelmaking was improved. The ways of supplying the air grew better. Tools and machines for digging iron ore were made bigger and stronger. As better steel was made, the furnaces and engines, the derricks and cranes, — everything made out of steel, — was improved too.

To understand the remarkable things that science and engineering are doing today, we must, of course, study the problem much more fully than we can do now in this book. In your later studies you will do so. But one final thing we can do before we leave our study of steel and what it does for us today: we can imagine what our world would be without it.

What a Funny World!

Imagine for a moment what America would be like if we had no iron or steel! In our houses we would have no furnaces in the cellar to give heat. Cooking would be done over the fireplace as our great-grandmothers did it. On our farms we would plow the ground with wooden plows, possibly tipped with bronze if we were rich and could afford it. Rakes, hoes, and the like would be of wood. Sickles and scythes, axes and knives, perhaps would be of bronze; if not of that, we would be back in the New Stone Age with the ancient Egyptians and Chinese.

In the cities — well, if there were cities they would be like villages, with low buildings of not more than

three stories. Here and there some daring "engineer" might have built a skyscraper of four or five stories out of stone and brick and concrete.

How would we move about? No locomotives or cars on steel rails. No electric generators or engines of any kind. No busses or trucks or airplanes. Just horses and oxen or other animals — or else we would walk!

On the water, only sailboats or rowboats! No steel liners; in fact, no steam or motor boats because there would be no engines. We would sail or row or swim!

Our clothing? We might raise the cotton if we lived in a hot region; or if we lived in a cool one, we would raise sheep and shear them, spin our own yarn, weave it into cloth, and make the cloth into garments. We would prepare hides of animals and make them into shoes and belts and harnesses and other things.

As for — but, do we need to go on? You can add many examples of what our world would be like if we had no iron or steel. It would be like — well, the Egyptian or Assyrian or Chinese way of living we have been describing in the Bronze Age and in the New Stone Age of from 5000 to 10,000 years ago.

So much do our lives today depend on iron and steel.

Books You Would Like To Read

FRASER, CHELSEA. Secrets of the Earth. Thomas Y. Crowell Company, New York. The story of mines and mining.

STONE, G. L., and Fickett, M. G. Days and Deeds a Hundred Years Ago. D. C. Heath and Company, Boston. Historic stories of great inventions: cotton gin, steamboat, telegraph.

WILHELM, D. G. The Story of Iron and Steel. Harper & Brothers, New York.

CHAPTER XVI

Tools and Machines Today

TWO IMPORTANT parts of the story of man at work have passed before our eyes. We have seen his remarkable success in inventing new kinds of power and new materials. In place of muscle power and other kinds of *natural* power, he learned to make *mechanical* power in steam or gas or electric engines. In place of stone and wood he learned how to use copper and iron and other metals, how to mix them as alloys to make the strong steel of our machine world, and how to use concrete and many other new kinds of materials.

But materials and power alone were not the only things which changed man's way of doing work. What he could do with these depended on his *tools*. Throughout all his life on earth man has always had tools. Even the branch of a tree which early man broke off to use in killing an animal was a tool. Throughout all his history these tools have been to him real "power aids." Without them he could not have done his work.

Now that we have read the story of materials and the story of power let us go back to the story of how men invented their tools and their other power aids.

The Power Aids of Ancient Peoples

How long have people known the power aids that the children of Miss Harrison's group were discussing? We do not know exactly, but most of them were known to the Egyptians and other peoples several thousand years ago.

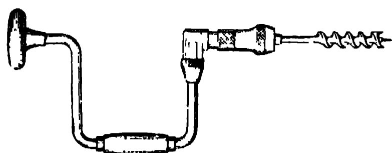


FIG. 128. A bit and bitstock. Did the ancient peoples have a tool like this to bore holes?

Which tools did these ancient peoples have to help them in their work? Let us see.

For pounding, there were hammers of various sizes.

For chopping, there were axes of stone and bronze and copper.

For pulling and lifting, there were rope pulleys, inclined planes and rollers, the wheel and axle, and the screw.

For cutting, there were saws — both the small ones which a single man could use and the long ones which two men could swing back and forth between them.

For boring holes, there were the carpenter's awl and drill.

For digging, there were hand shovels, or scoops, held by two men and pulled by a pair of oxen, like a plow.

For smoothing things, there were planes and chisels.

Power Aids of Europeans in 1500 A. D.

It seems likely that by the time Columbus discovered America most peoples of the earth, except some of the very simplest of nature peoples, had either invented these kinds of tools or learned from other peoples how to use them. Certainly that was true of the people who lived in England and France, Spain and Italy, and other European countries.

We know that before 1500 A. D. European inventors had made such things as the following:

Windmills	Sawmills
Guns	Paddle-wheel boats
Cannon	Velocipedes
Paper	Canal dredges
Printing presses	Different kinds of gears
Stone-arch bridges	Belt drives
Magnetic compasses	Pumps
Silk-reeling machines	Spindles
Wire-pulling machines	Parachutes
Spinning wheels	Canal locks
Mechanical clocks	Globes
Rudders for ships	Link chains
Treadle looms	Roller bearings
Water-driven ironworks	Cranes

That is a short list of inventions made by Europeans between 1000 and 1500 A. D. Do not try to remember them. We give them simply to show you that hundreds of years ago the thinking people of Europe were making many new tools and devices to help them to do their work.

Were the Old Power Aids Tools or Machines?

Most of these inventions were fairly simple. They were really *tools.* One should really not call them *machines.* When James Watt was trying to turn the old Newcomen pump into a steam engine (about 1765), there were no steel blast furnaces, no great rolling mills, no electric cranes to lift and move things, no big steam hammers, no railroads. In fact, if we use the word *machines* as we do today, one could safely say that there were no real machines.

Even the hand tools that the workmen of that day used to cut and pound, plane and smooth, were very crude, and they knew almost nothing about how to make things out of iron.

Do you remember how James Watt complained about tools and about the lack of skilled workmen? "How can I ever make an engine," he said, "unless I can get a boring tool that will make a really round cylinder? And give me a workman who knows how to use it! ' he added; for he knew very well that even if he got the accurate tool, there were few workmen skilled enough to know how to use it.

So while the English mine-owners tried to get inventors to make engines that would pump the water out of their mines, the inventors were asking for tools with which these very engines could be made. They were soon to discover, however, that tools were not enough. Machines were needed to do the heavy and complicated work that was coming into the world.

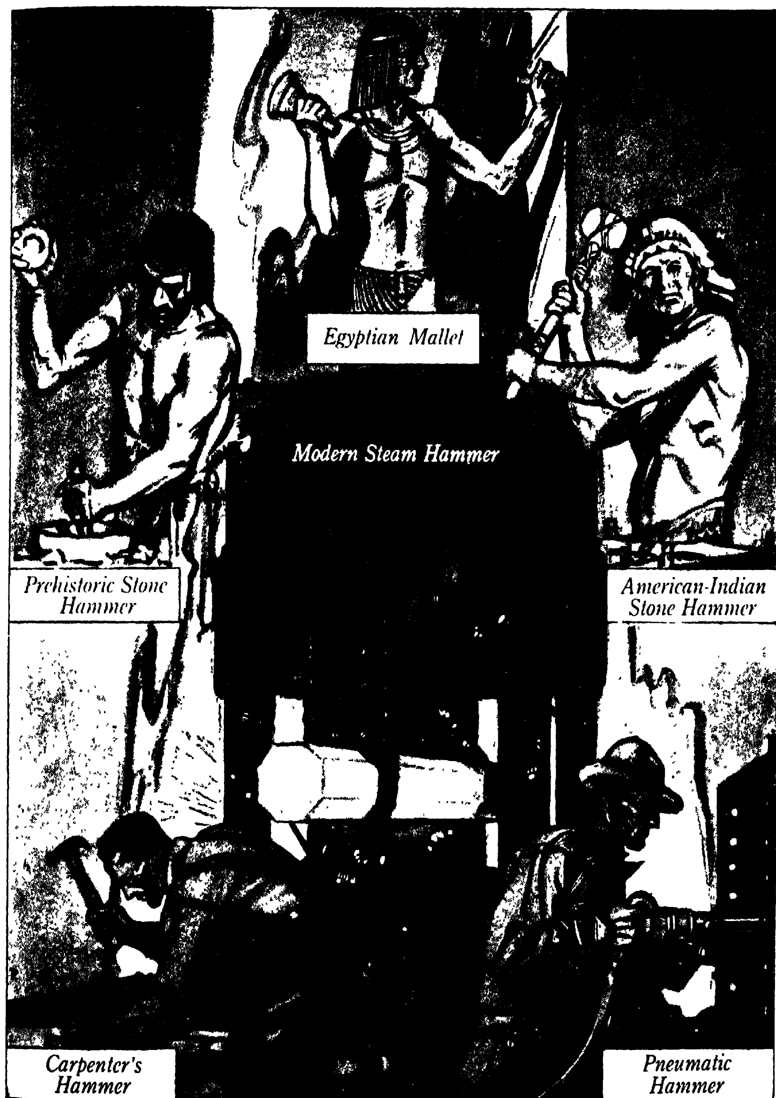


Fig. 129. The story of the hammer from early times

Perhaps you are asking, "What is the difference between a tool and a machine?"

There are no sharp differences; in some respects a tool and a machine are very much alike. But there is one difference between them that it is important to know. If we see how tools and machines work, we can see what that difference is.

Differences between Tools and Machines: Shoveling

Think for a moment of one kind of work — shoveling. In figure 130 you see men working with hand shovels. The men are stooping, lifting, and throwing shovelsful of dirt, one at a time. It is fairly simple work. Two things are required to do it. They are power and skill: muscle power to push the shovel, to lift it, and to throw the dirt on it, and a little skill to guide the shovel. Almost any human being can learn to do it.

Now consider the steam shovel (figure 131). It is run by a man who sits on a platform and moves levers. His work is to watch carefully and be quick in judging where the shovel should dig. He must be skillful in moving the shovel with the levers. The shovel does the work of digging.

We call the hand shovel a *tool,* and we call the steam shovel a *machine.*

What is the difference?

First, notice that with the hand shovel, the tool, almost all the work is done by the workman's muscle power and skill. His muscles supply the power, and



Fig. 130. The hand shovel: a few pounds of earth and aching muscles



Fig. 131. The steam shovel: several tons of earth at one bite





Ford Motor Company

FIG. 132. One screw at a time by hand

FIG. 133. This machine tightens 16 screws at once

his eyes, arms, hands, and fingers supply the skill. The tool has taken over a little of the work of shoveling, but very little.

Now think of the way the steam shovel works. Its engine supplies all or nearly all of the power. The shovel has been so built that it can make the movements, one after another, that are needed in digging. The crane (derrick) that holds the big scoop can swing around; it can move forward or backward. It can pull up or drop down; it can open and close the bottom of the scoop.

Of course the workman sitting in his seat must make the machine go through these movements. Even with

this machine the workman's skill is still required. His eyes and his mind have to decide where the shovel is to work and how it is to work. He moves bars in certain ways, and the crane swings around and stops over the exact spot where he wants it to dig. He moves another bar, and the big scoop drops down and pushes forward into the dirt and rocks. Another movement, and the shovel lifts the two tons of earth, swings around over a freight car, and the bottom of the scoop opens. Down drops the earth into the car.

You see that with the hand shovel the power is supplied by the muscles of the man, and his hands and arms make the movements. But the steam shovel takes over most of man's work; it supplies nearly all the power and makes nearly all the movements. That is the important difference between the tool and the machine.

Another Example: Moving Things

Take the work of lifting and moving things. In figure 86 you saw a girl pulling up a heavy suitcase with a pulley; in figures 80 and 81 you saw men pushing things up on levers and rollers. Although these are aids toward helping to increase man's power, the men's muscles and their skill are doing most of the work.

In the frontispiece you can see the work being done by a great lifting magnet with a single man moving the levers. One lever guides the enormous thing down its railroad track. Another raises and lowers it. Still another turns on the current, which lifts the steel bars.

This magnet can lift and move as large a load as could a thousand men using the simple power aids we have discussed. In fact, the thousand men would get into one another's way so that no one would work. Can you imagine men trying to pick up such a pile of heavy steel bars?

So we see in this case also that a man is needed to start and stop and direct the machine; but the machine's engine supplies the power, and the machine makes the movements which do the work.

In many chapters of this book we have already seen how machines work for Americans today. What a number and variety there are and what complicated things they do! You saw machines for spinning yarn and weaving cloth . . . machines for making a shoe . . . machines for doing many kinds of work on the farm.

Look back through the book and see the pictures of the many machines that are all around us. Three important things will come to mind:

First. Work is done by two things: (1) power; (2) movements.

Second. In our world today engines supply much of the power, and machines are doing more and more of the movements.

Third. Engines and machines are doing more and more of the work of human beings.

These examples showed the chief difference between the ways that tools and machines work. Now let us see the differences in the amount and kind of work that they do.

Amounts of Work a Man Can Do with Tools and Machines

Let us think back to some of the examples we have seen.

1. The 76-foot water wheel could make 30 times as much power as a horse and 300 times as much power as a strong man.

2. The 12,000-pound steam hammer can strike the red-hot steel ingot with 1000 times as much force as a man with a 12-pound hammer.

3. A farmer with a gasoline tractor can plow many times as many acres as the same farmer with a horse and a hand plow.

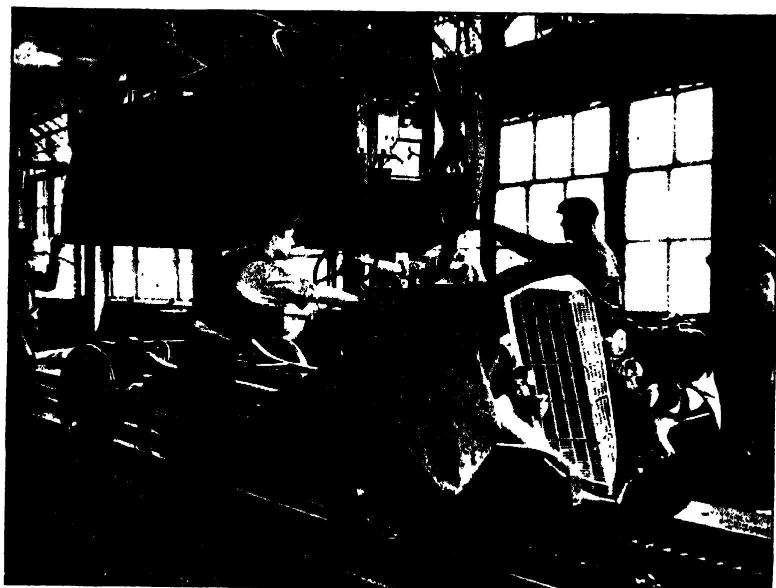
4. A large baking company can bake 100,000 loaves of bread in a day in one of its great city factories. In her kitchen oven grandmother could bake — how many do you think?

5. The two Nigerian natives made 10 pounds of pig iron a day in their hand forge. One of the blast furnaces of a steel corporation, using only a few men, turns out 1,000,000 pounds in a day.

6. In the old-time shoemaker's shop a very skillful workman made a single shoe in a long working day. By using power and machines one shoe can be made in a modern shoe factory in 20 minutes.

7. An automobile frame, made up of hundreds of separate parts, can be put together at the rate of 10,000 a day, using only 200 men.

8. A large glass company has a bottlemaking machine that will make 100,000 bottles in a day.



Ewing Galloway

FIG. 134. Putting an automobile together by power machines

Do we need to give more examples to show that a man using a power-machine can do many, many times *more* work than the same man using a hand tool? You and the pupils in your class can collect other examples, if necessary, to prove it.

Men with Machines Can Do Much of Our Work Better than Men with Tools

Some people will admit that machines will do more work than men. "But," they will say, "do they do it as well?" Let us see.

Consider the long steel railroad rail. The top of it must be perfectly smooth so that the car or locomotive



Hoedt Studios. Courtesy of *Fortune*

FIG. 135. Machines like this make thousands of bottles a day

wheels can run over it without bumping or being thrown off. Skilled workmen with hammers could not possibly pound a red-hot rail smooth enough. But when the giant rolls of the steel mill have finished it, it is flat and smooth! The machine is more exact than the worker's hand.

The farmer's machines plow furrows that are straighter, mix the soil more evenly, and put in the seeds more regularly than any farmer can do it by hand.

The flour-grinding machines separate the parts of the wheat berry and use each of them in exactly the right amount to give the kinds of bread that are desired.

The bread-mixing and baking machines make loaves that are of exactly the same size and shape.

The machines that prepare milk and meat produce the same products of the same kind day after day, year after year.

The spindles of the textile machine spin yarn better than the hand-spinner can do it. The loom weaves cloth more evenly. The sewing machine makes more even seams than does the seamstress.

Of course for some kinds of work, such as digging ore and the like, exactness and regularity are not so important; but in most work done by machines today it is very important. Perhaps you are asking, "Are there any kinds of work that people can do better 'by hand'?" There are, indeed. In our next book, *Man at Work: His Arts and Crafts,* we shall learn about those. Remember at this time that we are speaking only of the "heavy" industries, such as farming and preparing food, spinning and weaving and making garments, and building things of iron and steel.

Books You Would Like To Read

MORGAN, ALFRED. The Story of Skyscrapers. Farrar & Rinehart, Inc., New York. A complete story of the building of a skyscraper: cement, blast furnaces, how steel is made, how a derrick works. This applies to all skyscrapers, but especially to the Empire State Building.

WILLIAMS, A. How It Is Made. Thomas Nelson & Sons, London. How various machines and many articles in common use are manufactured from raw materials.

PART VII

Transportation and Communication

IF BY some astonishing accident all our trains, automobiles, and airplanes and all our telegraphs, telephones, and radios should stop running today, how would that change our ways of living? Let us see.

Your food, your clothing, and your shelter — do they depend upon trains and autos, boats and ships, telegraphs and telephones? What would happen to your other ways of living if all these ways of travel and sending messages stopped running today? Your recreation — would that be changed? How would you go to the next city or the next state to visit your relatives or friends? How would you get to school? Could people travel far or quickly? Could they send messages promptly?

These things — trains, autos, airplanes, and ships — are called means of *transportation.* When we speak of all or several of them together, we use the one word *transportation.* When we speak of several of the others — telegraphs, telephones, radio, the postal system — we use the one word *communication.*

Let us go back a bit in history and find out how it was that man learned to transport things and to send messages at the very same time that he was learning to build things.

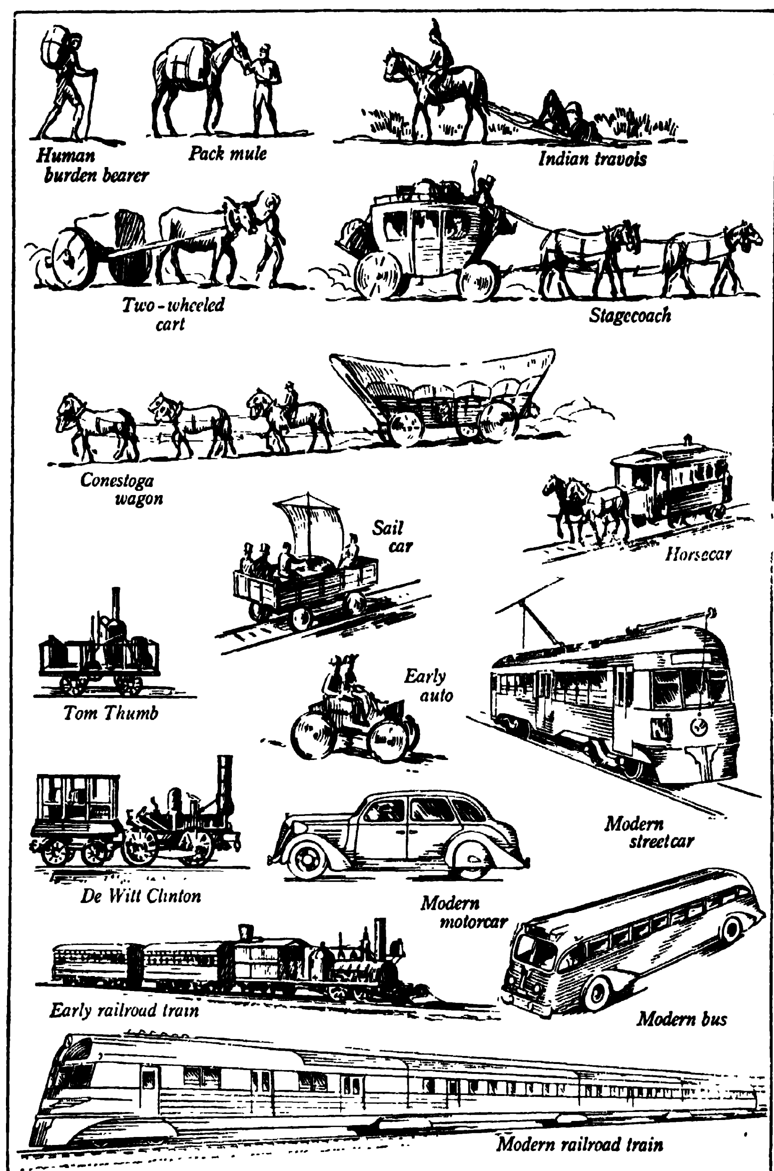


Fig. 136. A picture of land transportation throughout the ages

CHAPTER XVII

Wheels and Roads

LOOK ABOUT you for a moment at the mechanical things, — the things that move, — trains, wagons, autos, airplanes. What is it that helps them to move easily? "Power," you say. Yes, that is true; but there is something else. *Wheels!*

1. Think of things that move on land:

   Trains: Their locomotives have ten, twelve, even sixteen wheels.

   Cars: All of them run on wheels.

   Automobiles, trucks, busses: All move on smoothly turning wheels.

   Bicycles, roller skates: They whiz along on wheels.

2. Think of things in the air:

   Airships, airplanes: Their propellers (wheels) whirl around to make machines fly through the air.

3. Think of things on the water:

   Motorboats, steamboats, ocean liners: Their propellers whirl around to make ships move through the water.

Someone once said that the history of our ways of living is really the story of the wheel. Certainly in the history of transportation the chapter on the wheel is as important as the chapter on power. Let us see now how men invented the wheel to give them better transportation.

In the Days Long Ago before There Were Wheels

Imagine a day in the life of Old Man Neanderthal, of 50,000 years ago, whom you met at the "squatting place" in *The First Book of the Earth.* He has just succeeded in beating a bear to death with a stout oak club. He sits down near the body and begins to eat. After he has eaten all he can, he suddenly remembers that "Mrs." Neanderthal, who usually goes with him on his hunting trips, has stayed behind at the cave to care for the baby. Old Man Neanderthal knows that she is expecting him to bring back some food, and while he has a man's dislike for carrying bundles, he decides that he had better not go back empty-handed. So, with much grunting and complaining, he throws what is left of the bear's body over his shoulders and carries it to the cave (figure 137).

That was "transportation" in the days of Neanderthal man and for a good many thousands of years after his time. Muscles of men provided the power, and man himself was his own "beast of burden."[1]

Animals Become Beasts of Burden

From the story of power you also know that after a long time men learned to use animals to carry their burdens and to drag their loads. In every region they used whatever animals were near which they could

[1] Suggestions for this story came from *Timely Railroad Topics* No. 47, October 20, 1924. Published by the Atlantic Coast Line, Wilmington, North Carolina.



FIG. 137. Old Man Neanderthal brings home the bear



FIG. 138. The Stone Age people used sledges like these for transporting things

tame. If these "beasts of burden" were all brought together, they would make the most interesting menageries ever seen in a circus. There would be elephants from India; camels from Arabia and Africa; donkeys and asses from Palestine, Sicily, and other countries around the Mediterranean; llamas from the Andes Mountains of South America; carabaos (water buffaloes) from the Philippines and Siam. There would be sluggish oxen, shaggy ponies, wolflike dogs, sturdy horses, and, last but not least, "wise-eyed, slant-eared mules." On the backs of these and others the world's things were carried for no one knows how long. In many places, even today, they are still so carried.

Man Begins To Invent Vehicles

It is easy to understand that men grew tired of carrying loads on their backs and wished for something on which they could place their things while moving. Perhaps the descendants of Old Man Neanderthal made crude sledges, or drags (figure 138), on which their skins and tools could be pulled. No doubt by the time they had tamed animals like the ox, they hitched them to such rough vehicles. Writings on ancient stones show us that the Egyptians were riding such "drags" pulled by asses even 6000 years ago. In other parts of the world peoples were harnessing llamas and yaks, camels and reindeer, dogs and elephants (pages 164 and 165). Later in Asia, and then in Asia Minor, northern Africa, and Europe, horses were used to pull sledges of one sort or another.

Even today in the northern part of the United States people use sleds and sleighs during the winter. In country districts, as soon as the first real snowstorm comes, out come the sleighs. Horses are hitched to them, and across the snow they slide.

Friction Again!

But you will note that there are runners on the sledges which make them slide easily on snow. That is one reason why they can be used in winter and not in warm weather. The ice or snow is very smooth and the runner is thin and polished, so that even a heavy sled can be pulled over the ground very easily. If you slide downhill on sleds in winter or go skiing, you know that there is very little "friction," or sticking to the snow. But when you come to a bare place where there is no snow, what a difference in the sliding or pulling! Why is that? Because the whole length of the runner now sticks to the dirt or stone or concrete of the road, and there is much friction.

The early Egyptians and Assyrians met this very same problem with their sledges. How could heavy sledges be pulled easily over bare earth and stone? We are told by an old record that the Egyptians solved the problem by greasing the road! A man went ahead of the ox sledge and poured a kind of oil on the road. But sometime later they found a better answer. They invented wheels!

Studying the Wheel

Have you ever thought of what a wonderful invention the wheel is? Bring a cart or a bicycle or a pair of roller skates to school. Unscrew one of the wheels and study it. What are its important parts?

First, there is the round edge on which the cart rolls. That is the rim. It is kept from bending and breaking by spokes. The spokes run from the rim to the hub, which is at the center. To permit the wheel to move, a round bar called an axle is fastened under the cart and passes through the hubs of the wheels. It is on this axle that the wheels turn.

Now look carefully inside the hub. Do you see some little oiled metal balls arranged around the inside circular rim? Those are "ball bearings." They are used in the hub to let the axle turn without too much friction. Were it not for the ball bearings and the oil your wagon wheels would turn very hard and would squeak so loudly that your neighbors would probably complain about the noise. You can be fairly sure that if the wheels of your cart, your bicycle, or your auto squeak, they need oil to reduce the friction of an axle rubbing on the hub.

Perhaps you are saying, "Of course; I know all that." We will agree; but remember that for many thousands of years people let axles turn in hubs without knowing that ball bearings or grease would reduce the friction. Such ideas are very new.

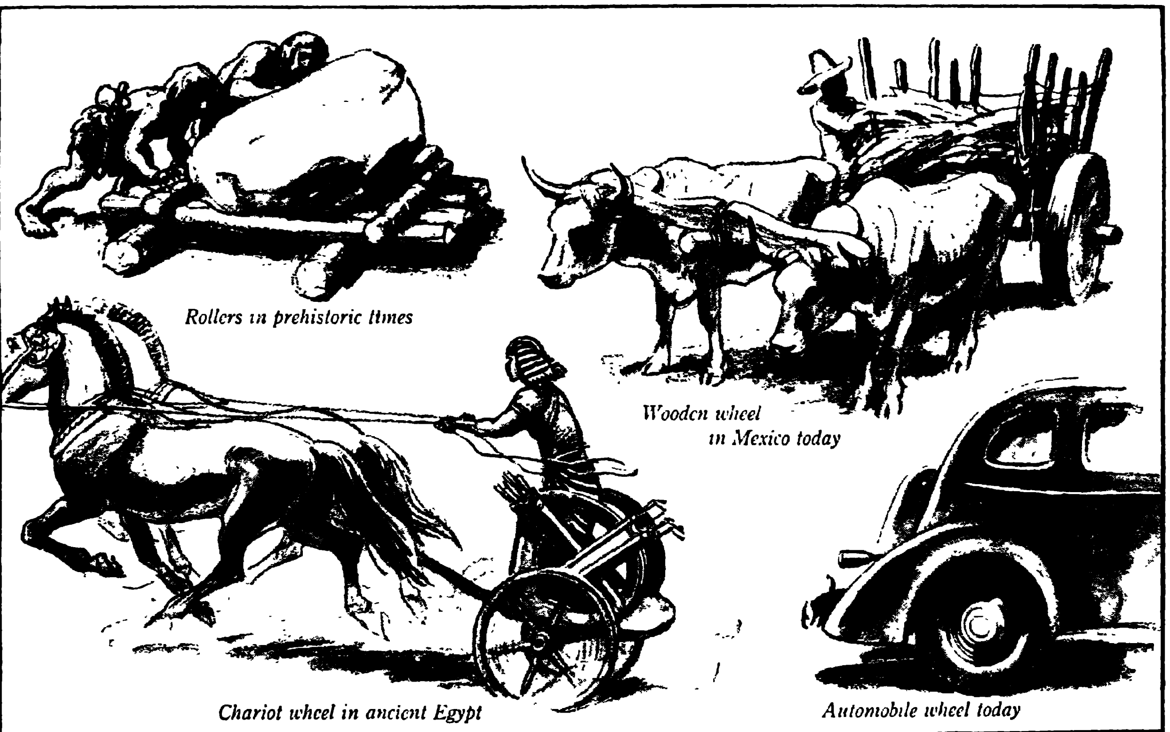


Fig. 139. A picture story of the wheel

Let us say again briefly what a wheel is. It is a rim . . . a central hub in which the axle turns . . . spokes holding the rim and the hub together.

Man's Long, Long Struggle To Invent the Wheel

It sounds simple enough when you take a wheel to pieces, does it not? But what a time human beings had to discover how to invent the pieces and put them together!

History cannot tell us the name of the man or men who invented the first wheels. Perhaps it was a lazy cave man who preferred using his head to straining his back. Perhaps, after stumbling over a log, he got the idea that he could roll the log more easily than he could carry it. But at last, certainly 4000 years ago and perhaps earlier, came the first wheels. No doubt at first they were "rollers," with a platform laid on two logs, as in figure 139. The logs were probably loose, and someone had to keep slipping them underneath the sledge platform as it moved.

Then someone, or more likely many different "someones," thought of a better idea. They cut off a solid slice of the log to make a wheel. The picture in figure 139 shows a cart used today for transporting goods in Mexico. You can see that there are some countries where some of the wheels are now, as they were at first, simply slices cut off logs. Solid wheels, however, bend and split. They are very heavy and hard to drag or push and are quickly worn down by hard, rough ground.

So another "someone" thought of burning or digging a hole in the center for an axle and attaching the axle to the body of the cart or wagon. Who did it . . . when they did it . . . how they learned the idea of an axle turning in a hub . . . we do not know!

Many thousands of years must have passed before men began to use a wooden hub or even spokes and a rim. But sooner or later they did! By 2000 B.C. broad roads were running into the city of Babylon, in Asia Minor; so we are sure that the people there must have had wheeled vehicles. By that time there were roads in Egypt, in Assyria, and in Persia. Wheels and vehicles had become very much better, as pictures on ancient writings prove.

Notice in figure 139 the sketch of an Egyptian war chariot of several thousand years ago. It has a real wheel, with rim and spokes and center hole, in which the axle turned.

Vehicles Begin To Carry Passengers

Perhaps the first real passenger vehicle was the chariot — the carriage of warriors and noble rulers. It had two wheels and was built on a frame from which a pole, or shaft, stuck out. To this pole the horses were harnessed. The body of the chariot was open in the back, and there were no seats. The driver stood (see figure 139). Often a warrior stood beside him.

All the peoples around the shores of the Mediterranean used the chariot, but we are not sure who were

the first to use it. The Egyptians improved it perhaps more than any of the other ancient peoples. They decorated their harnesses and trappings for the horses as well as the parts of the chariots themselves.

By 800 B.C. the Greeks were making chariots that were lighter and more graceful than those which the Egyptians had known. They used beautiful woods and ornamented them with silver and gold and other metals. Brass tires covered the rims, and drapes of rich material hung on the sides. Some of the peoples who lived near the Greeks built a kind of house above the body of the chariot and put in a seat.

Sometimes bulls were used to pull these chariots, but generally throughout this region horses supplied the power. A thousand years before Christ the wealthy nobles and rulers of Babylon raised splendid horses. One of their rulers is said to have had a stable of 2400 horses. The best of these were chosen for the chariots of the king and for racing, which was a popular sport even in those days.

The chariots of the ancient peoples were also made into terrible war vehicles. They were called scythe chariots because long knives or short curved sickles and spears were fastened to the wheels and sides of the chariot. You can imagine the slaughter of human lives as a warrior drove his horses at top speed through a company of enemy soldiers. Later this way of carrying on war spread all over the Roman Empire, and we are told that in 54 B.C. the Britons fought the great Roman leader Julius Caesar with scythe chariots.

So we can be sure that by the time of Christ the use of the chariot extended to the west all the way from Persia, through Europe, to the British Isles. How far east into Asia it was in use we are not sure.

Wheels Depend upon Roads

Before we go on with the story of wheels and vehicles we must stop for a moment to talk about roads. Has it ever occurred to you how closely the two are tied together? Have you ever had any experiences which would make you think of it?

Not long ago the authors of this book learned how important a road is when a great cloudburst came in the Catskill Mountains, followed by a rainstorm which lasted for two days. Our house is on a mountain looking down on a valley, at the end of which is the country store where we buy our food. After a day of rain, water poured off the mountains in all directions and began to fill the lowlands of the valley where the road wound along. Higher and higher it rose.

As we watched the water steadily rising we began to understand that soon the road would be covered and we could not reach the store. Then, quickly, we got out the car, sped down the winding road through the rising water, and bought food to last for several days. Then we drove back through the water, which was up to the hubs by then, and up the mountain to the house. Just in time! In another hour the water was several feet deep, and the road could not be traveled. Soon bridges were washed away by the torrents that roared

down into the valleys. Then we realized how much we depended on that road.

Since there are so many good roads today, most Americans do not understand how important they are. We have 3,000,000 miles of roads in the United States. Nearly everywhere we go, from Maine to California, we can travel on concrete, macadam, or hard gravel roads. Even most of our dirt roads are smooth enough for automobiles.

Lack of Roads in Asia and Africa

But there are hundreds of millions of people on the earth who have lived in civilized ways for thousands of years who have almost no roads! The Chinese are an example. They are the people with the longest unbroken history on earth. Yet even today some of their largest cities are not connected by roads. As recently as 1932 the authors of this book rode over a new automobile road for 200 miles from the famous city of Hangchow to Nanking, the capital of the country. That was the first road ever to be built connecting those two cities.

From Nanking we walked over narrow footpaths to villages near by. No roads! From a town a few hundred miles from Peiping we rode on donkeys over narrow footpaths to the neighboring villages. No roads! So it is, all over China!

That was the way most people in the entire world lived for thousands of years. Although the Babylonians and the Sumerians, the Egyptians and the Greeks, had

roads going out from their great cities, the people in most of the smaller communities lived by themselves. One could tramp for weeks around the Mediterranean seacoast and north into Europe without finding a single road!

The Famous Roman Roads

When the Romans came, however, and conquered the whole known world around the Mediterranean Sea, things changed. More than 3000 miles long and 1000 miles wide was their empire, with thousands of communities, hundreds of different kinds of people, all ruled from the one city of Rome on the little river Tiber in Italy!

How do you think they were kept together in one empire for several hundred years? Several things made it possible, of course, but one thing helped more than anything else — roads! The Romans built smooth roads that wagons, as well as horsemen and people on foot, could move over quickly. Business men could travel from place to place, buying and selling goods. Governors in parts of Europe far away could send messages to the rulers in Rome. Armies could travel quickly to put down any trouble and to keep order.

Because of good roads Roman ways of living spread outward from the Mediterranean all over Europe. At one time there were in the Roman Empire about 400 different main roads nearly 50,000 miles in total length. These highways were from 12 to 15 feet wide, were

made of stone and gravel, and were well rounded so that water would run off the sides. So well were they built that 800 years later some of them were still in good condition. Even today some of the roads of Europe are built over the old Roman roads.

The most famous of these Roman roads was the Via Appia, "the Appian Way," a 350-mile highway from Rome to Brindisi, in the south of Italy. Along this road the East and the West, the North and the South, met and passed. Black-skinned Africans and dark-skinned Syrians and Arabs, Hindus in their white gowns with turbans on their heads, and blonde Germans from the north; soldiers and sailors, merchants and peddlers, nobles in their fine chariots and beggars — all passed in this busy procession.

No Improvements in Roads or Vehicles for 1500 Years

But that was nearly 2000 years ago. Rome slowly went to pieces, and her rulers lost control over the faraway places. As you know from *Peoples and Countries*, Europe divided into hundreds, even thousands, of separate communities. New countries were slowly forming.

During these years the fine Roman roads, of course, were allowed to go to ruin. Few new ones were built; and since there was no order such as the Romans had kept, they were rough and dangerous to travel over. So far as we know, chariots went entirely out of fashion, and nothing but the crudest of carts and wagons were in use.



Forti

FIG. 140. A scene on the Appian Way in Rome



FIG. 141. How comfortable do you think traveling was in a coach like this on a road like that?

About 1500 A.D. the Story of Roads and Horse Vehicles Begins All Over Again

Just before 1500 A.D. a new interest in vehicles began. By that time kings and queens were ruling over England and Spain, France and Portugal. Hundreds of little German states were growing up where Germany and Austria are today. Each of these had a ruler who wanted to ride in a comfortable carriage. "Comfortable" is scarcely the word to describe the vehicles of those days, for they were really only boxes on wheels. Chairs were set on a platform, and curtains were nailed on posts to hide the passenger from the gaze of the peasants.

Emperor Frederick III of Germany gets the credit for having the first coach, and 1474 A.D. is the date when he rode in it. There is some doubt, however, whether he was the first to risk his life in such a thing. Other nobles of the time in Europe also claim the credit for it.

From that time on, coaches of every shape and description appeared. In all the cities of Europe the nobles rode in their carriages. There were two-horse coaches, four-horse coaches, six-, eight-, even ten-horse coaches. The square box gave way to a curved body like that in figure 142. Fixed seats took the place of loose chairs. Curtains of leather were added to protect the passengers from the rain or snow and cold. The silks and satins of the furnishings were ornamented with gold and silver.

But, with all their improvements, the coaches were uncomfortable to ride in. We who sit on stuffed automobile seats over steel springs, and ride on smooth cement highways, can hardly realize what it meant to jolt over those rough mudhole roads in boxlike wagons with no springs. Velvet and silk drapes and gold and silver ornaments were fine for decoration, but they did not increase one's comfort much.

Nearly 300 years went by. In the meantime the rulers and the lords and ladies and the rich merchants continued to ride in their coaches within the cities. The peasants, the city workers, and the small shopkeepers walked or else rode on donkeys or in rough carts. As more people began to travel, livery stables were set up where horses and carriages could be rented. Then regular horse-drawn coaches ran between the larger cities.

Few people rode for long distances, however, because of the dangers from robbers and from the bad condition of the roads. Hardly a coach went through from Edinburgh, Scotland, to London, a distance of about 400 miles, in less than ten days. Today one gets into a sleeping car in London in the evening and wakes up next morning in Edinburgh. And, of course, there is rarely a breakdown or a robbery.

Slowly, very slowly, during the 1700's roads were improved. Some of the ancient Roman roads were cleared off and rebuilt. New roads were constructed.

John McAdam: The Father of Our Roads Today

Shortly before 1800 A.D. an English engineer by the name of John McAdam began to work on the problem of roadbuilding. He experimented with a new kind of road. First he put in a deep stone base which was broad and curved high in the center so that the water could run off the sides. Then he rolled a layer of finer stone above the heavy stone and coated the top with a layer of very fine stone dust. This made a road that was better than any that had been built since Roman days.

McAdam went about over England building roads, putting down altogether about 1000 miles. Soon engineers from other countries heard about him. They went to England to study his method, then went back to their homelands and copied it. Today, instead of stone dust, we use tar or some other good surface covering, but we still call these paved tar-surfaced roads "macadam" after this man, who is called the "father of the modern surfaced roadway."

Slowly carriages were made stronger, and iron springs were installed under the seats. Phaetons and gigs and brouettes and other types of carriages appeared. By 1800 it was estimated that there were 20,000 four-wheeled passenger vehicles in little England alone. How many there were in France, the United States, Germany, and other countries we can only guess.

Wheels and Roads in America

You already know from *The Building of America* some of the things that were happening to transportation in our country. After 1800 the trail-blazers were cutting paths through forests and over the plains, in and out of the river valleys through the mountains. New villages appeared as the frontier moved westward. More people came over the mountains and settled in them. As the years passed, the villages grew into towns, and many of the towns grew into cities.

More people meant more trade. The farmers needed the goods of the town, and the townspeople needed food and other farm products. The pioneers of the West began to trade with the business people of the East.

As you know, trade could not go on without transportation. So after 1800 the people of the United States turned to building roads and railroads, to digging canals and improving rivers for steamboats. Soon macadam roads were seen, in the country as well as in the city. The National Road was built across the Appalachians, connecting the East with the West.

Then all sorts of vehicles went rumbling over these new roads. "Concord" coaches and others of the new stage lines hauled their passengers from town to town. Inns and taverns along the roadsides did a thriving business. Year after year new settlers moved westward across the continent. And behind them were built the roads which they had begun to make as trails. A big plan of transportation was being started.

While the settlers were traveling west in their red, white, and blue Conestoga wagons the people of the Eastern cities and towns were improving the style of their vehicles. The first private coaches of the new United States had been copied from the European ones of that time. Washington himself had set a fashion in 1791 by making the famous 1900-mile trip as President in his White Coach (figure 142). Soon after that, in all the larger cities from Boston to Charleston, South Carolina, the well-to-do had their coaches.

Slowly the big coaches gave way to smaller vehicles for a single person or for two or four persons. In the cities business men started companies for making carts, wagons, Conestogas, coaches, buggies, and carryalls.

The "buggy" (figure 143) became one of the most popular of these smaller vehicles. About 1830 a builder by the name of Carter set a new style by making a buggy with thin wheels, steel springs, and "fancy trimmings." That started a race. All the builders wanted to make the finest buggies.

At first buggies sold for $500, and few people could afford to buy them. Then came Jacob Huntington, with his idea of turning out hundreds of buggies at a time and selling them at a low price. At one time the price went as low as $32, although this was really less than what it cost Huntington to make them. Other business men imitated Huntington, and a race started between them — a trade war. But now the "common people" began to buy buggies, and by 1850 a thousand factories were making them.

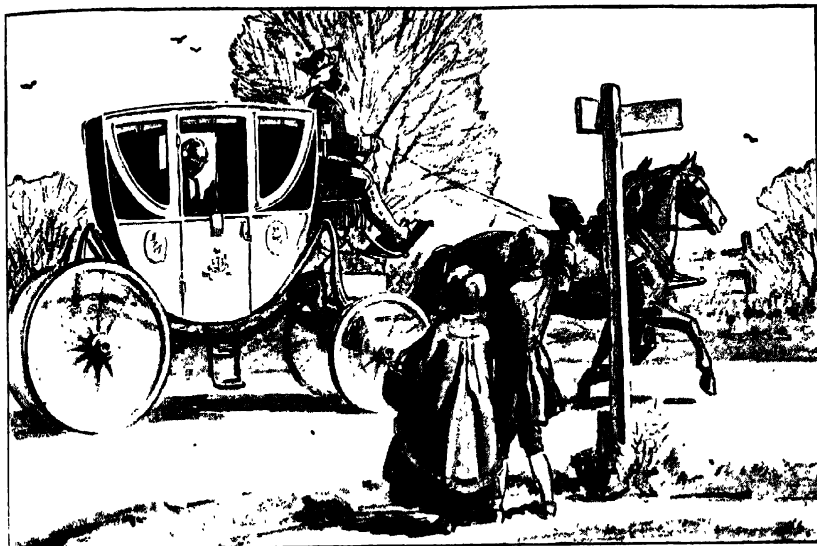


Fig. 142. President George Washington traveling in his famous White Coach



Fig. 143. The horse and buggy took the farmers to town before the days of the automobile

By 1890 buggies and other horse-drawn vehicles were being made all over the United States. At one time in the 1890's there were 8000 carriage factories which turned out 2,000,000 carriages in a single year. Listen to the names of a few of the manufacturers of buggies and see if you recognize them: Studebaker, Durant, Fisher. Do you know what business they are in today?

Of the many improvements which were made in these private family carriages, the rubber tire was the most important. An English inventor had made the first one in 1876, but they sold very slowly. Can you guess why? People said that they would be dangerous to walkers on the street because they would be so quiet that no one would know that a carriage was coming! By the 1890's, however, they were being used on most private carriages.

Then Something Happened and Almost All the Carriages Disappeared

This brings our story of roads and vehicles to about 1900, to about the time when your fathers and mothers were born. Up to their time the power of road transportation was provided chiefly by animals — oxen on the farms and horses in towns and on the highways. Eight or ten miles an hour was the speed limit, and tired bodies was the charge that people had to pay for riding far in vehicles drawn by animals.

After 1900 all that was to change. Can you imagine now what it was that changed the ways of road trans-

portation? Something did; for although 2,000,000 carriages were built and sold in one year in the 1890's, only 2600 were sold in 1932.

What happened to them is another story — the story of exciting attempts to invent new things. Let us read about it in the next chapter.

Books You Would Like To Read

BUSH, MAYBELL G., and WADDELL, JOHN F. How We Have Conquered Distance. The Macmillan Company, New York. The history of transportation and communication.

CHAMBERLAIN, J. F. How We Travel. The Macmillan Company, New York. Simple accounts of travel in use all over the world.

DALGLIESH, ALICE. America Travels. The Macmillan Company, New York. From stagecoach days to modern times in travel.

FOX, F. C. How the World Rides. Charles Scribner's Sons. The story of transportation as it grew in America.

HADER, MRS. B., and HADER, ELMER. The Picture Book of Travel. The Macmillan Company, New York. The story of transportation on foot and by animal and machine power.

ROCHELEAU, WILLIAM F. Great American Industries. Fourth book. A. Flanagan Company, Chicago. Early methods of travel and transportation.

TAPPAN, EVA MARCH. Travelers and Traveling. Houghton Mifflin Company, Boston. How railroads are built and run, and how they carry mail and people; freight and express; refrigeration in bringing us food; transportation by rivers and canals, roads and bridges.

WALDEN, A. T. Harness and Pack. The American Book Co., New York. The animals which have carried and hauled freight in America.

WEBSTER, H. H. Travel by Air, Land, and Sea. Houghton Mifflin Company, New York. The history of all the modes of transportation.

CHAPTER XVIII

The Iron Colt

The First Experiments

IN 1769, about the time when James Watt received the patent for his steam engine, a French army officer, Nicolas Joseph Cugnot, built the queer-looking steam locomotive shown in figure 144 and drove it on the streets of Paris. For the first few blocks things went very well. The crowds watching this strange vehicle held their ears at the deafening roar and rattle. They laughed and they booed. But as it went block after block they had to admit that it did "locomote"! At least it did until Cugnot turned a corner! Then the lopsided, three-wheeled thing turned over! How the crowd jeered and called out to "put another wheel under it." Nor was that all. The police came and threw the inventor into jail. After that steam-cart invention was very much slower in France for a long time.

But funny though it was to the people on the street, and sad though it was for the inventor, the event was perhaps one of the most important in the history of transportation. For the first time in the history of the world man had invented a machine that would move without wind, without water, without man's muscles, without animals' muscles. Machines would now propel themselves; they would be *self-movers.*



FIG. 144. Curves were too much for Cugnot's three-wheeled locomotive



Harold Sichel

FIG. 145. Richard Trevithick driving his steam locomotive in 1801

What Made These New Self-Movers Possible?

How did it happen that these things were invented and came into use just about 1800? From your study of power you can probably answer that question yourself: it was because *engines* had been invented. James Watt's engine was a success about 1780. Soon afterward thinking men began to see that perhaps this engine could be made to move things, just as it could be made to do useful work while it was remaining in one place.

A hundred years before James Watt's success in building an engine the famous English scientist Sir Isaac Newton had suggested a way to drive a wagon by steam. Heat water in a boiler . . . fasten the boiler on a platform with wheels . . . use the force of the escaping steam to turn the wheels. Those were Newton's directions for making a vehicle that would go by itself. But Sir Isaac was a scientist who thought up new ideas; he was not much of an inventor; so he did not try to make a "locomotive" or an "automobile" that would go. Neither, so far as we know, did anyone else for nearly 100 years.

Then came many "funny" experiments, like Cugnot's three-wheeled velocipede. Like Cugnot's, all of them seemed to go well for a time; then something would go wrong. In some the boiler was not strong enough for the steam, and they exploded; in others the wheels were in the wrong place, and they tipped over; or they could not be steered, or they were too

heavy for the engine, or the engine was too heavy for the body, or something was wrong. But they did *go*!

Watt's Assistant, Murdock, Builds a Toy Steam Cart

People in England told James Watt about Cugnot's steam cart and urged him to make a "locomotive." But Watt would have nothing to do with the idea. It was all very well, he said, to use steam to pump water and perhaps to run spinning machines (although he was not sure about even that) but not for making things move. They would surely blow up! Of course the men who were in the business of using horses to pull stage-coaches agreed with him. They did not wish to see steam take the place of the horse, for it would ruin their business. In fact, most people in Europe were so slow to accept new ideas that they laughed at the steam carts.

One of James Watt's assistants, William Murdock, did not agree with either Watt or the others who doubted that steam could make things move. While working with Watt, Murdock had learned much about steam engines. Knowing that his employer was opposed to steam wagons, however, Murdock made one in secret. It was really nothing but a toy, standing less than two feet high. Murdock could pick it up and carry it in his arms.

Murdock was wiser than Cugnot in trying out the new engine. He took it to a lonely English country road. And there he proved his point: that even if it was only a toy, a steam engine would propel a cart.

In 1801 the Steam Cart Becomes the First Automobile

Why Murdock never went ahead with his idea to make a large vehicle that would carry people, we do not know. But his toy was important, for it gave the idea to Richard Trevithick. Trevithick saw Murdock's steam cart and studied it. Then he too made a toy cart in 1796 that would really move itself, and later he decided to make a big one. In 1801 he succeeded.

On Christmas Eve of that year he drove the steam cart out of the shop (figure 145) through the streets of Camborne in Cornwall, England, beyond the village, up a fairly steep hill, and back to the shop again.

Trevithick and Murdock and Cugnot — yes, and Isaac Newton — were right! Watt was mistaken, or was he only jealous? A steam engine could be fitted on a wagon and made to propel the wagon along the roads.

Here, then, was the first real automobile. Of course it was not yet useful to many people, but Trevithick showed that it could be made so. It would take more money to build bigger and bigger engines, so Trevithick took his steam auto up to London on a boat and ran it for ten miles through London's streets. But the "man on the street" just laughed, and the well-to-do London business men refused to invest any money.

Rails Enter the Story

Up to that time these steam vehicles were road automobiles. They were run on roads, and people thought of them as "steam carts." But now there was to be a

great step forward. Failing in London, "Captain Trevithick," as his neighbors called him, took his steam wagon to the owners of some coal mines in southwestern England. Would the mine-owners be interested?

They would be, indeed. They were spending large sums of money to have their coal hauled from the mines to the city of Plymouth, a distance of nine miles. Mules and horses were pulling the coal wagons over a track of wooden rails. A steam "horse" would certainly be welcome.

Now, tracks of "rails" were not a new invention. They had been in use for hundreds of years in various places. In England iron ore and coal had been transported from the mines on tracks. From the story of wheels you can see why people took to rails instead of continuing to pull their wagons over roads. Wheels on rails made less friction than wheels on rough dirt roads.

The first rails were made of timbers, or logs, spiked down and held in place by crosspieces of logs. Later the timbers were fastened to stone blocks set in the earth. To keep the wagon wheels on the track, a strip of wood was nailed on the side of the rail.

The First Automobile Becomes the First Locomotive

When Trevithick arrived at the mines, he began to set up his engine. First he had to rearrange the engine wheels to fit the tracks of the coal mine. When everything was ready the steam cart was put on the track, and off it started. For nine miles it ran without trouble. This was on February 10, 1804. A few days

later it pulled five cars loaded with seventy passengers and many tons of freight over the whole distance at the undreamed-of speed of five miles an hour! To the best of our knowledge this was the first railroad in all history. The iron "colt" was now a success!

For some years Trevithick's locomotive continued to run, although some people, especially the owners of horse-drawn wagons, talked against it. Then an accident happened. The locomotive ran off the track and smashed up. The coal-mine owners would not rebuild it.

In the meantime other inventors were carrying on his idea. In 1812 John Blenkinsop had an engine made. It was crude. The engine was small. It would go only four miles an hour. But it would pull a whole train of coal cars, and for twenty years it puffed and rattled back and forth from the city of Leeds over its wooden railway.

Hackworth and Hedley Make *Puffing Billy* in 1817

Again we see how one invention led to another. In 1812 Timothy Hackworth, a foreman in a coal mine in Newcastle, and William Hedley, a mining engineer in the same place, made a steam wagon that not only worked but looked more like what we know today as a locomotive. It had a barrel-like boiler and a tall smokestack which gave a fine draft to the fire. The thing worked so well that the inventors were encouraged to try again, and in 1817 they built a second one and named it *Puffing Billy* (figure 146). That was such a success that it worked, day in and day out, for 47 years. In 1864 it was retired to a historical museum.

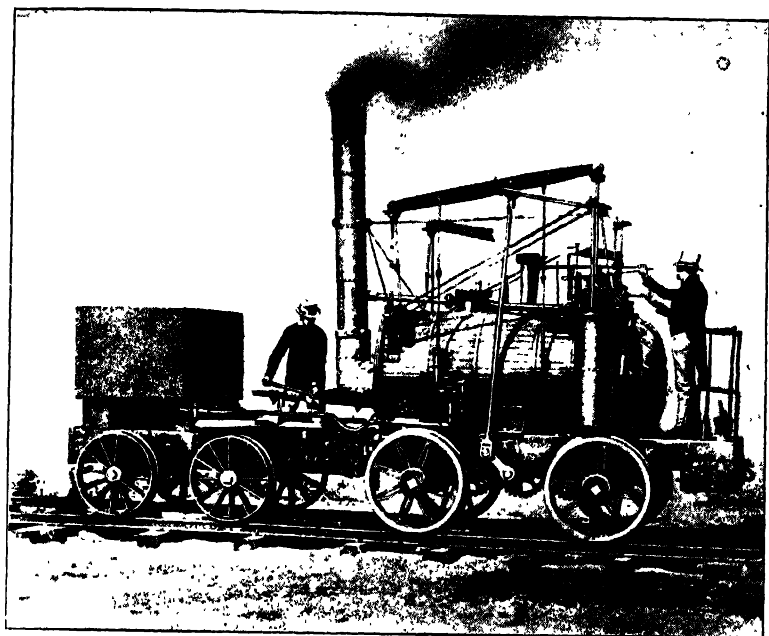


FIG. 146. This is Hackworth and Hedley's *Puffing Billy*

Did All People Accept Railroads?

So we see that before 1820 some people in England knew that vehicles moved by steam could be used successfully. A few daring inventors knew it. The coal-owners knew it, for "locomotives" were transporting their coal. But did all people accept the railroads as a fine new way of carrying themselves and their goods from place to place? No, indeed. There were several groups who opposed them from the very beginning.

First, there were the people who were afraid of anything new.

Second, there were those who thought that the engines were noisy and dangerous. The sparks from their smokestacks set fire to fields and houses and people's clothes. They frightened cows and horses. They should not be used.

The third and most important group, however, were the owners of stagecoaches, canal boats, and freight wagons. They made money by transporting passengers and goods. They knew that people would not travel in their vehicles if the railroads succeeded. So these men would think and wait a long time before they would give permission to build something that would destroy their own businesses. And they did wait!

The inventors went on inventing better steam "locomotives" (as they were being called by the 1820's), but they could not convince people that they ought to be bought. What they needed was a man who was both engine-maker and salesman — one who could sell the idea to others as well as make the engines.

George Stephenson, the First Railroad Inventor-Salesman

George Stephenson was such a man. In 1798 he was a boy working as an engine helper in an English coal mine. He was bright and soon learned enough about the engine to repair it. From that time on he was determined to know everything there was to know about engines and to build them himself. He studied all those he could find, including Trevithick's locomotive and Hackworth and Hedley's *Puffing Billy.*

By the time Stephenson was thirty-three years old he had built a locomotive. But, more than that: he was such a good talker that he succeeded in getting some coal-owners to let him try it out at their mine. The experiment failed, and the coal men sent Stephenson away, but he was not to be discouraged.

In 1815 Stephenson set up his own engine shop in Newcastle and then did a very clever thing. He hired Timothy Hackworth, who had made *Puffing Billy*, to be his chief mechanic. It is said that for several years Hackworth worked out many of the engineering ideas while Stephenson went about trying to persuade people that railroads should be built in England. He succeeded too. Within the next ten years his shop built several locomotives for coal-mine owners, and Stephenson had made himself the best known of the steam-wagon makers in England.

In 1821 a group of English business men in Stockton and Darlington got permission from the government of England to join the two towns with a twelve-mile railroad track. The story goes that the members of the government understood that horses were to pull the trains; otherwise they would not have given their permission. But no sooner did George Stephenson hear of it than he went to the business men and urged them to try steam engines. They agreed to do it. So while the workmen built the track (it took four years to build twelve miles) he and Hackworth built a brand-new engine and called it *Locomotion.*

On September 27, 1825, came the trial. The *Loco-*

motion, driven by Mr. Stephenson himself (dressed, we are told, in a long coat and a high silk hat), left Stockton, pulling a long train of 34 "waggons." On these were nearly 500 people, as well as many tons of coal and other freight. It was an exciting day, and the whole countryside turned out to see the new steam wagon. The brass band in one car played tunes, and people shouted and cheered as the engine got up steam and pulled the long train faster and faster along its track. Its speed increased until it rose to 15 miles an hour! Darlington was reached without a single accident.

People were now convinced that the new locomotion was successful. In spite of what the stagecoach and canal-owners thought, other lines were suggested. Timothy Hackworth himself built a locomotive which was called the *Royal George,* named, no doubt, for George IV, who was then king of England. This went faster and burned less fuel than Stephenson's.

All over England calls came for the new transportation. In the manufacturing and trading cities of Manchester and Liverpool business men raised the astonishing sum of $2,000,000 to build a road between the two cities. The government was forced to give permission. There were even contests to decide which locomotives were the best. George Stephenson and his son Robert built a new one called the *Rocket,* which finally won over the others. Stephenson was now regarded as the great locomotive-builder of the day.

From that time on, railroads were built to connect

the large cities of England and Scotland. Small cross lines were built between the main roads. Other engineers experimenting with locomotives found out how to make more power; how to burn coal instead of wood. Passenger cars became bigger and more comfortable. Long steel rails replaced the old wooden and stone ones. Train workers became more skillful. It became a busy time of railroad-building.

Other Countries Began To Use Railroads

Although English inventors and business men made the first workable steam railroads, France, Belgium, Holland, Germany, and other European countries soon followed their example. In the 1830's the first tracks were laid between Paris and other cities. By 1850 one could go by railroad to almost any large city of Europe.

You already know, from *The Building of America,* that during the very years that Trevithick and Murdock and Hackworth and Stephenson were experimenting with steam wagons, American inventors were also trying new ideas of transportation. Some of these they had learned from James Watt and the other Englishmen, but some of them they had thought up for themselves.

There was an important business reason for much of their work. You remember that during these same years Americans from New England, eastern New York, Pennsylvania, and New Jersey had been moving westward over the Appalachian Mountains to find homes in

the fertile land of the Ohio valley. In the 1790's hundreds of miles of hard roads had been built connecting the towns of the Atlantic plain. Now the people were beginning to construct roads along the river valleys and through the mountains to the new West.

By 1820 people had moved as far as the Mississippi River. Several hundred thousand men, women, and children were living in the regions west of the Appalachians. These people depended upon the Eastern cities — New York, Philadelphia, Boston, and Baltimore — for tools, household utensils, farming implements, nails, drugs, and other necessary things which they could not produce in the wilderness. The Eastern people in turn wished to secure the furs, foods, and other products of the frontier.

It was Oliver Evans who did for America what Trevithick had done for England. As early as 1804 he made a combined steam wagon and boat which he drove through the streets of Philadelphia and on into the Schuylkill River. But in America, as in England, the people jeered at Evans and the other inventors and would not help them.

Peter Cooper, Business Man and Locomotive Inventor

But if England had her George Stephenson, America had her Peter Cooper. Cooper, like Stephenson, was both a mechanic and a business man. Moreover, he had money and owned a large stretch of land near Baltimore. He saw that if the railroad could be made a paying thing his land would be very valuable; so he

showed what a good business man he was by investing money in the new Baltimore and Ohio Railroad. It was planned to have horses pull the cars, but Cooper persuaded the men in the company to use a steam locomotive.

Cooper had been studying the steam wagons of other inventors, so in a few months' time he built a funny little locomotive which was well named the *Tom Thumb*. You know the story of what happened on August 28, 1830, when it pulled forty people over the thirteen miles of track to Endicott Mills and even reached the shocking speed of eighteen miles an hour for a time!

On the way back from that trip, you remember, Cooper was asked by one of the leading stagecoach men to run a race. Cooper accepted. The race began, and for a time the train was beating the horse-drawn coach. But a belt on the locomotive slipped off its wheel, and the horse ran in ahead. For some time afterward Cooper was laughed at, and the stagecoach men seemed to have the better of it but not for very long. Cooper and other inventors soon improved their locomotives, and railroads began to take the place of horses.

In the meantime other cities were building railroads. Charleston, South Carolina, put the *Best Friend* (figure 147) into the running in 1831 after selecting it in a prize contest. Soon 136 miles of track were laid, reaching to the western part of the state.

In that same year the *De Witt Clinton* (figure 148) made its famous run, and soon trains were chugging

up and down the Hudson River valley and through the Mohawk valley, connecting New York with the West. Philadelphia, Boston, and other cities followed soon after, and engine works were opened all along the Atlantic plain. Matthias Baldwin, a clockmaker, went into the locomotive business, and in a few years his locomotive works became one of the most famous in the world.

Only a few years later the business men of Ohio, Illinois, Indiana, and other Western states were also building railroads. Even west of the Mississippi River farmers and business men were joining hands to build tracks between the towns. By 1860 one could travel and ship goods by railroad from the Eastern cities to Chicago and the other new cities of that section.

In 1869 Railroads Joined the Atlantic and the Pacific

While the railroads were being built in the eastern part of the United States, settlers were pushing out into the vast plains and mountains beyond the Mississippi. As late as 1870 people were still moving to the West and making new homes. California and Oregon were growing. The prairies between the Mississippi and the Rockies were slowly filling up with people.

Roads were still rough, and horse-drawn vehicles were slow and could carry only small freight. Large and heavy things had to be transported by ocean vessels around the tip of South America and north along the west coast.

People soon began to see that much time would be

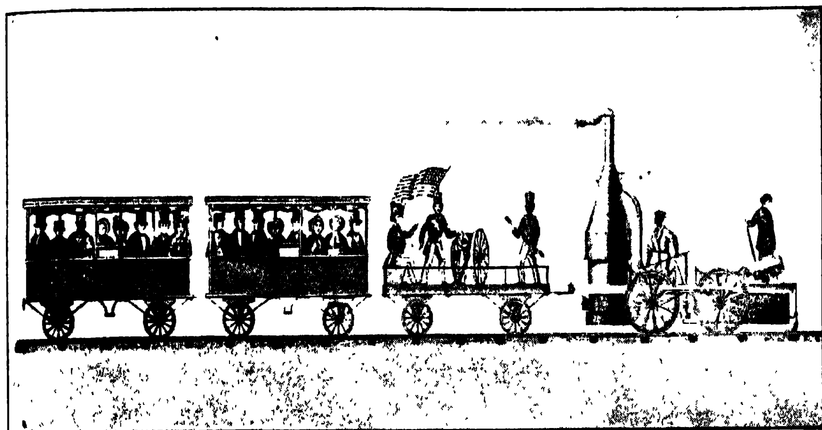


FIG. 147. The *Best Friend*, 1831. One of the first steam trains in the South

FIG. 148. The *De Witt Clinton*, 1831. One of the first steam trains in the North

saved if goods could be shipped across the continent. Railroads would do that very thing.

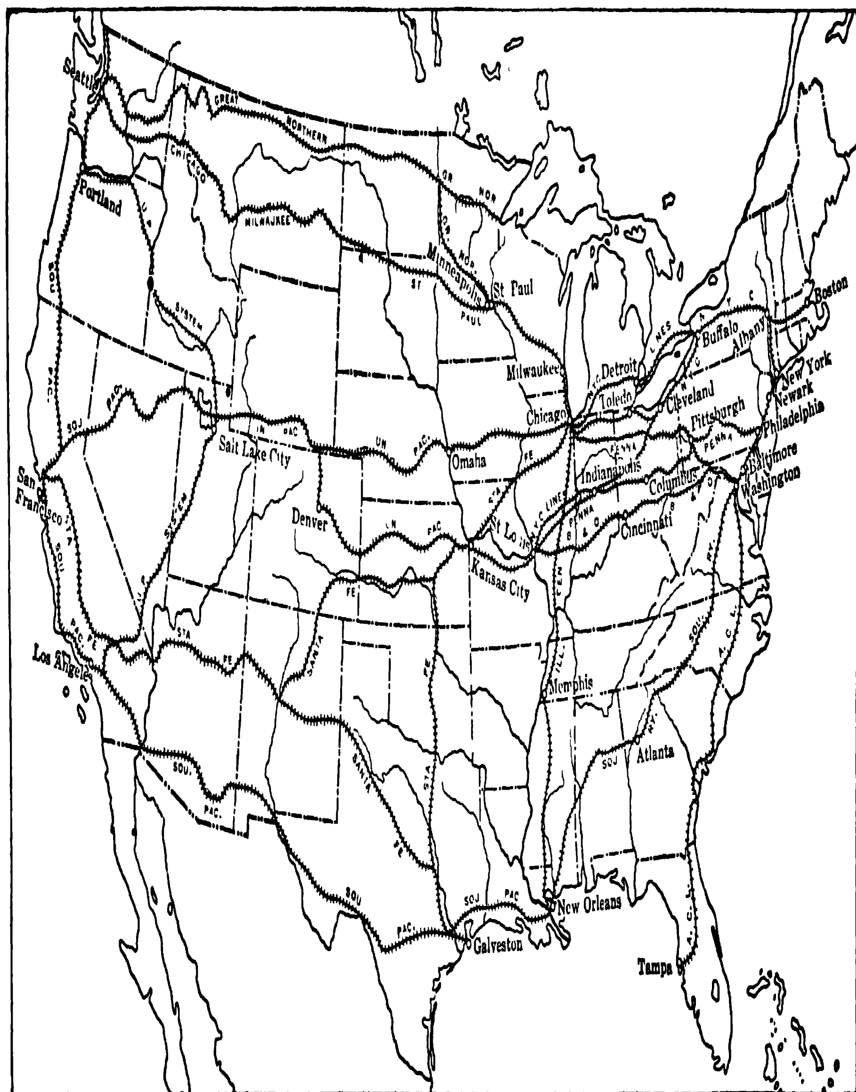
So two companies were organized to build the first road. One started at the Pacific coast and worked eastward; the other began in Iowa, where the Eastern rail lines ended, and worked westward. The two gangs worked toward each other at top speed, surveying, fighting Indians, and laying rails all at the same time. On May 10, 1869, they met, at Promontory Point, Utah. The completion of the first transcontinental railroad was celebrated as a great event in our history. East and West were tied together.

What 100 Years of Railroad-Building Have Done

After this important event of building the railroad across the continent, other large systems were built throughout the country. You can see what a busy time these years were when you compare the number of miles of track in the early years and the number not so long ago. In 1830 there were 23 miles of track; in 1930 there were 250,000 miles!

Compare the modern locomotive with the engine of the little *De Witt Clinton* train (shown in figure 148). Do you see how the size and power have increased? Each time a new engine is made the designers think they have reached the limit in size. In 1875 a locomotive weighed about 40 tons; today it weighs several hundred tons.

As locomotives and cars became larger and heavier it became necessary to make other improvements. The



MAP 4. The railroads of the United States

rails were made much stronger; these are now of steel instead of brittle iron. Today the roadbed, which holds the rails firmly in place, is made of heavy crushed rocks, rolled cinders, or the slag taken out of steel furnaces. All these are carefully laid so that the road will support the heavy loads. The bridges which carry our trains safely across rivers are no longer of wood, as were the first railroad bridges. They are strong, lasting structures of steel and concrete. Instead of long, difficult routes over the mountains, tunnels have been cut through them. Railroad engineers have certainly been at work during these years.

As we write, still other improvements are being made. Many railroads near large cities have been electrified; that is, the trains are run by electric power instead of by steam. In transportation, as well as in manufacturing, electric power saves fuel and does better work.

The Railroads Do the Work of Transportation

Have you ever watched the trains go by and thought of all the work they do for us?

They carry us on long trips to every part of the country. But carrying passengers is not all that they do, although without trains we should have to stay at home more than we do. Their big work is carrying freight. Many more cars are used for goods than for people. You can see that by comparing the figures below for one year.

Passenger, baggage, and mail cars	57,000
Freight cars	2,590,000

Every day, every night, every hour, long freight trains are winding through valleys and across plains, bringing us goods of all kinds. What is each of these carrying? Out of a hundred cars, fifty-five are filled with products of the mines — coal, iron ore, copper, and the like; twenty-six contain manufactured things; nine carry products of the farms; eight carry lumber and other products of the forest; two carry animals and animal products.

As you watch a freight train go by, counting the cars as they pass, what do you see? Box cars, flat cars, coal cars, refrigerator cars, tank cars, livestock cars, even special cars for milk, poultry, and other products. Can you imagine what a tremendous job it is to handle all this freight?

Even though you may seldom ride on a railroad train, the railroads are working for you every day. They are carrying coal to the factories which prepare your food and make the cloth for your garments; they are bringing gasoline for your automobiles, carrying furniture for your houses, and hauling a hundred other things to markets where you may purchase them.

The growth of our railroad system is another example of the astonishing changes brought about in the past 150 years. Watt's tiny engine for pumping water was the seed of an idea which helped to make possible the 250,000 miles of railroad that carry the people and goods of the thousands of communities throughout the United States to one another.

But Watt's crude engine was also the beginning for more ideas of transportation than locomotives and railroads. Other "self-movers" were to appear on the scene which would change all our ways of living.

Books You Would Like To Read

COOLIDGE, ALBERT S. Building a Model Railroad. The Macmillan Company, New York.

HAYES, MARJORIE. The Little House on Wheels. Little, Brown & Company, Boston. Two children living in the 1830's have a ride on a train drawn by the first locomotive.

HENRY, R. S. Trains. The Bobbs-Merrill Company, Indianapolis, Indiana. A history of railroading in America, telling about the development of equipment.

HOLLAND, R. S. Historic Railroads. Macrae-Smith-Company, Philadelphia. A history of the steam locomotive in England and North America; also descriptions of some of the most remarkable railroads in other parts of the world.

LENT, H. B. Clear Track Ahead! The Macmillan Company, New York.

MEIGS, C. L. The Wonderful Locomotive. The Macmillan Company, New York. A little boy takes a train across the country on its last run.

NATHAN, MRS. A. G., and ERNST, M. S. The Iron Horse. Alfred A. Knopf, Inc., New York. The development of the locomotive.

PRYOR, W. C. The Train Book. Harcourt, Brace and Company, New York. A photographic picture book and story, telling the experiences of a railroad journey.

REED, BRIAN. Railway Engines of the World. Oxford University Press, New York. Excellent descriptions of the great locomotives on the principal railways of the world.

SWIFT, H. H. Little Blacknose. Harcourt, Brace and Company, Inc., New York. The story of a pioneer — the first locomotive on the New York Central Railroad.

VAN METRE, T. W. Trains, Tracks, and Travel. Simmons-Boardman Publishing Company, New York. The evolution of travel by train, with interesting photographs.

CHAPTER XIX

From Steam Cart to Horseless Carriage

Did the Automobile Come before the Locomotive?

IF YOU should tell your great-grandfather that the automobile came before the locomotive, he might say, if he were a very old man, "Why I rode on the railroad in 1850, and I never even saw an auto until 1895."

"That might be true," you could tell him; "but Nicolas Cugnot and Richard Trevithick and William Murdock and Timothy Hackworth all made road automobiles. They called them steam carts or steam wagons in those days, but they ran on the roads and carried passengers. They were really autobusses and were made nearly 150 years ago."

"Well, why didn't we hear anything about them when I was a boy in 1860?"

"Because Stephenson and Cooper and the others began to run the steam wagons more easily and safely on rails. Then everybody got excited about the building of railroads. Europe and America simply went mad about railroads after the 1820's."

If you showed your great-grandfather the pictures of the early engines, he could guess other reasons why the railroad stole the place of the automobile in the hearts of the people 100 years ago. Look at *Puffing*

Billy (figure 146). Should you like to drive that big tub of boilers and machinery and a car full of wood or coal around on your errands to the grocer and the butcher? Should you like to park it in front of the school? No; the early steam engines were too big and too clumsy to be put on small carriages.

So your great-grandfather can well understand why most inventors spent their time making better steam engines for factories and railroads, rather than "automobiles" for the roads.

The Problem for the Inventors of Engines

During all the excitement over the big Watt steam engines and railroads a few thinking men kept working at the problem of making engines that would occupy only a little space but would have much power.

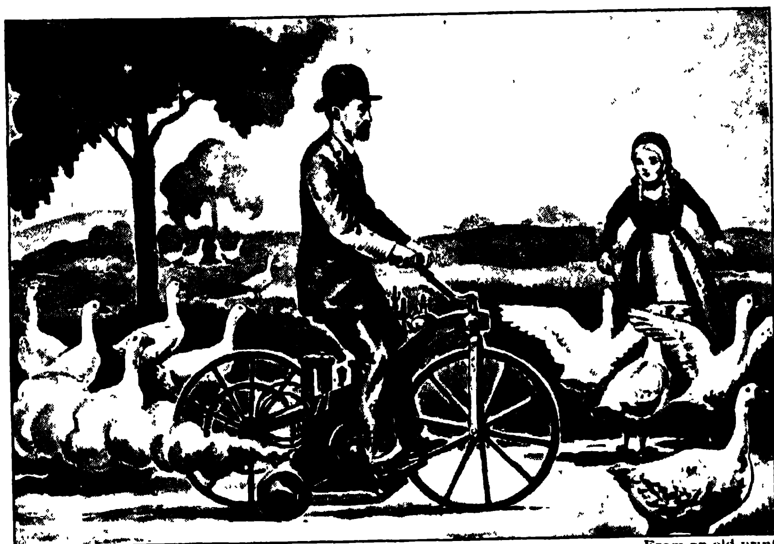
For 100 years inventors and scientists had talked about other kinds of engines. One kind was known as the "explosion engine." As early as 1670 Christian Huygens, the great Dutch scientist and telescope-maker, had tried with the help of Papin to make a gunpowder engine. "Fire gunpowder off inside the cylinder," said Huygens. "It will explode and force the piston up. But then," he would add, puzzled by the problem, "what would force it back? How can I get inside the cylinder and fire the next little charge of gunpowder, and the next one, and still others, so as to keep the piston going back and forth?" That question Huygens never was able to answer; nor could anyone else in his day.

Time passed, and, as you know, 100 years later Watt succeeded in doing a different thing, that is, in forcing steam into the cylinder from the outside. Huygens's idea of exploding something *inside* the cylinder was forgotten for many years. Now and then people talked about the idea and wrote about it; but, so far as we can discover, these models were never made into a real working engine.

Searching for Different Engine Fuels

Most of the men who experimented with small engines thought that the power for them would have to come from something besides steam. What kind of fuel could be used if not heated water? One inventor tried to burn kerosene, another tried benzine, several others tried gasoline. Still another tried just crude oil as it comes from the ground. That burned so well that it exploded in his face, smashed his engine all to pieces, and knocked him senseless. But when he "came to" in the hospital he was happy because he had proved that ordinary heavy oil would burn in a cylinder.

So the "crazy" experimenters went on building their funny engines, each one learning something new about what would explode in a cylinder and so move pistons and turn wheels. And, as in the story of other kinds of invention, the success or the failure of each one helped the others to know what to do next. We cannot tell here the whole exciting history of how the automobile was invented, but we shall give a few important parts of the story.



From an old print

Fig. 149. Gottlieb Daimler runs the first motorcycle in history (1885)

The Men Who Finally Made Horseless Carriages Go

In 1863 Étienne Lenoir's crude "gas" carriage rattled and banged with a deafening clatter through the streets of Paris and out beyond the city. Then Lenoir turned it around, and it rattled and banged back. This trip took three hours. The machine burned benzine, and the pistons moved up and down very slowly and very noisily. Although it did work, Lenoir became completely discouraged with the results of his experiments and finally gave up all hope of making a car that people would buy.

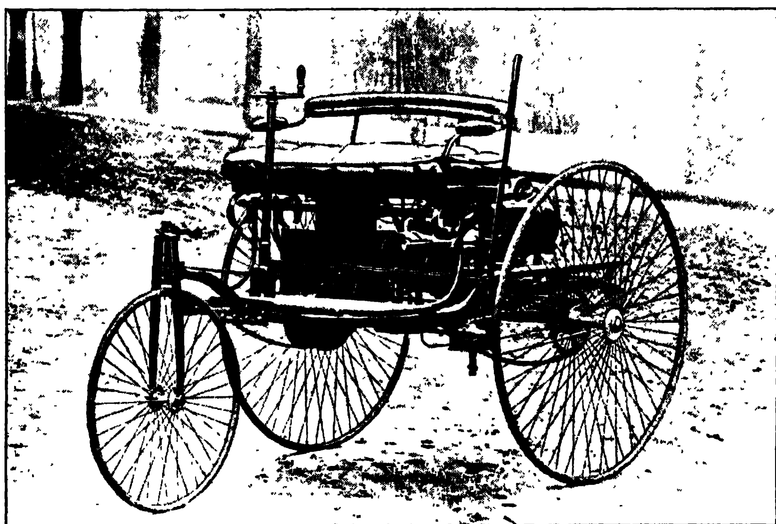
Ten years later Gottlieb Daimler in Germany started work on a gas-burning engine. In 1883 he produced

one that would move the pistons four times as fast as the engines of other inventors. Two years later he had solved the problem of connecting the engine to wheels. Instead of using a four-wheeled wagon, he hitched his engine to one of the newfangled bicycles just coming into fashion. Thus he made the first motorcycle in history (figure 149)! Later Daimler started a company which has produced more than 3,000,000 motorcycles.

Daimler also tried to invent a way to make his powerful engine turn wagon wheels; but while he was doing so, Carl Benz, another European, came forward with the best engine of all. If you look at its picture (figure 150), you may not think that it is so much like ours today. On the outside it looks like a big three-wheeled velocipede; but if you could look inside the engine and see it work you would understand that since Benz's time, 50 years ago, all gasoline motorcars have been built on the same idea.

Step by step the automobile stopped looking like the queer contraption of Cugnot and Lenoir and Benz and began to look more like our motorcars of today.

By 1890 Lenoir and Daimler and Benz had found out the two things that make an automobile. The first is that pistons can be pushed up and down without stopping by burning a gas in a cylinder. The second is that the moving pistons can be fastened to a wagon so as to turn the wheels. They had proved that gasoline wagons would go, even though seven or eight miles an hour was their top speed. But seven miles an hour was not to be laughed at! It was twice as fast as a man



Smithsonian Institution

FIG. 150. The first gasoline-propelled car, built by Carl Benz, a German, in 1883

could walk, and faster than a horse could pull a carriage all day long. "Don't forget," said the new horseless-carriage men, "the gas wagon doesn't tire out like old Dobbin; it can keep going as long as you give it fuel."

American Mechanics Began To Build Gasoline Buggies

Up to 1890 only one American had tinkered with gasoline carts. That was George B. Selden of Rochester, New York. Selden had built a small model of a car and had applied for a patent in 1879. But sixteen years were to pass before the United States government granted him (1895) the patent he had asked for as early as 1879.

But there were several other Americans who did experiment with old pieces of machinery until they succeeded in making gas engines that would go. Whether they knew or saw the European cars that were invented in the 1890's, or just worked out their own ideas one by one, we do not know.

The American cars were called "buggies" of one kind or another. Charles Duryea of Massachusetts, who built the first one in 1892 and 1893, called his a "buggynaut." "Well named," perhaps you think, as you look at it in figure 151. What Duryea did was to build an engine and fasten it under the seat of a one-horse buggy. He took off the poles to which the horse was fastened, attached a handle to the front wheel for steering, and turned the rear wheels with his engine.

Elwood Haynes, a traveling man for an Indiana gas company, did very much the same thing. While driving a poky old horse over Indiana roads he thought out a plan for attaching a gas engine to a buggy. First he succeeded in getting an old engine. After studying it, he made a plan for a new one and had a mechanic build it. Then he attached the new engine to a buggy. In the midst of a Fourth of July celebration in 1894, the buggy-car was pulled out of the town of Kokomo, Indiana, by a horse. The horse was then taken off, and Haynes drove the noisy, rattling thing into town to the surprise, even the cheers, of the people celebrating on the streets. Another self-moving horseless carriage had been built.

During the 1890's other Americans began work on

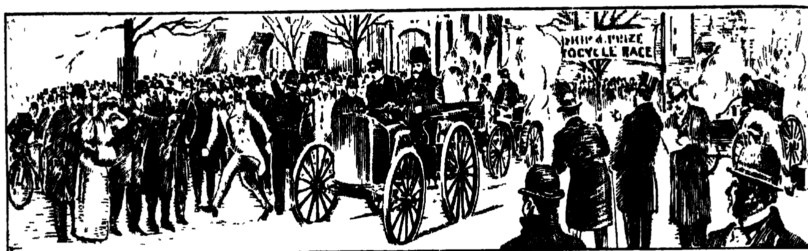
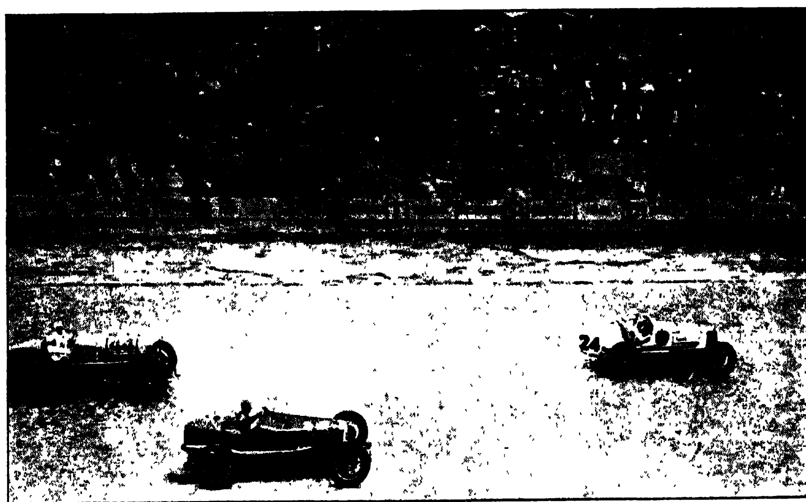


Fig. 151. A horseless-carriage race in 1895. Charles Duryea is driving his car. He traveled a distance of 53 miles in 10 hours, 23 minutes



Underwood and Underwood

Fig. 152. A modern automobile race. One of these cars would go the 53 miles of Duryea's race in less than half an hour

gas cars. Some of them are well-known names today. There were the two Dodge brothers and John P. Willys. These three had been bicycle-makers. There were also the Studebaker brothers, who had been manufacturers of buggies. And there was Walter P. Chrysler, who worked for a railroad company and succeeded in building an automobile that would work.

Driving a Car in 1900 Was No Picnic!

Do you imagine that in those days it was easy to sell one of these gas buggies to an American who was not a mechanic and knew nothing about machines?

"No, sirree!" he would say. "You never can tell when it's going to break down, or scare a horse into running away, or frighten a farmer's cows, or climb up onto the sidewalk of a crowded street and kill someone. Give me a horse. I know he'll go, and I'm safe!"

People stood on the streets and laughed at the drivers of the new machines. Someone even wrote a song which everybody was soon singing. It was called "Get Out and Get Under" and reminded people that motorists spent most of their time crawling under their cars to repair them instead of riding in them.

At that time cars had no self-starters, and everybody had to turn a crank to start the engine. Often an arm was broken when the crank whirled back suddenly. The steel used for the car's axles or steering wheel and other parts was not well made, and often it broke, causing serious accidents. Gasoline was full of dirt, and engines became clogged.

Tires were not well made. On a short trip drivers often had three or four punctures. Since there were very few garages and almost no filling stations, the driver had to repair the tires by the roadside and blow them up with a hand pump! Nor were there any jacks like the ones today, with which even a small boy can raise a heavy car. And, of course, there were almost no cement roads — just dirt roads that made the cars go bumping along!

Is it any wonder that most Americans shook their heads and went on "hitching up old Dobbin"?

Then Came "the Ford!"

In the early 1890's a young man got an idea which was to make it possible for more than twenty million American families to own an automobile. That young man was Henry Ford. Ford had been a mechanic in an electric company, but he had lost his job and was without money. Nevertheless he gathered together some pieces of old gas pipe, wire and wood, bicycle wheels, and an old buggy seat, and started to build a gas engine and a wagon. The story goes that when it was nearly finished he worked on it day and night without stopping. At last the motor would go.

One day in 1893 Ford got into the old rickety buggy seat, started the engine, and drove the car (figure 153) slowly out of the little shop into a pouring rain. The story is told that Mrs. Ford came too, walking beside the car and holding an umbrella over Mr. Ford as the patchwork engine chugged and rattled along.

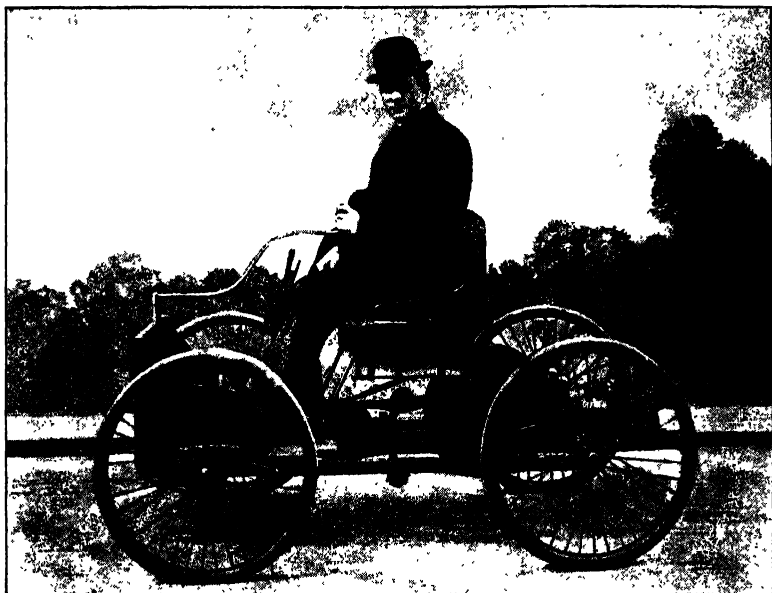


Fig. 153. Henry Ford sitting in his first automobile, 1893

For a few blocks the car continued on its way down the street. Then something came off (no wonder, for it was shaking wildly enough to shake everything off!), and it stopped. But were Mr. and Mrs. Ford discouraged? No, indeed. Their horseless carriage went, and Henry Ford was mechanic enough to know that he could repair it and business man enough to know that he could sell it.

And now Ford started to work on his idea. "The American people need a cheap car," he said. "They can't pay $4000 or $2000 or even $1000 for an automobile. Sell them one for $800 — no, $500, and you'll

put large numbers of cars on the road." The story is told that he sold his first car for $200 and at once began work on another. So he went on building an automobile and selling it, slowly improving on each new car.

But Ford also knew how to get his name and his car into the minds of millions of people; he took part in automobile races. The newspapers printed stories about the races and about him and his car, and so gave him a great deal of free advertising. In one race he beat Alexander Winton, a famous racer. Then he hired Barney Oldfield, who was known all over the country as a champion bicycle rider, to drive a specially made racer that he had built. Oldfield drove it for a mile in 1 minute and $1\frac{3}{5}$ seconds. The country buzzed with the report. A few months later Ford himself drove an automobile on ice at the rate of a mile in $39\frac{2}{5}$ seconds. The newspapers were full of the story, and the sales of Ford cars rose higher and higher.

As more cars were sold, Ford regulated the price, and generally kept it around $500 or $600. That price was within the reach of most families, and they bought and bought and bought.

How Could Henry Ford Sell Cars So Cheaply?

Perhaps you are asking, "How could Mr. Ford make a car cheaply enough to sell it for $500 and still make money?" For he did make so much money that today he is one of the richest men in the world. He did it by using several ideas. One was an idea that

Eli Whitney had thought up 100 years before. After Whitney had invented the cotton gin, he returned to Connecticut and began to make guns. Before this time guns had always been made by hand, one at a time. Therefore no two guns were exactly alike, since a person could not always make two parts in exactly the same way.

Whitney said: "It will be cheaper to make these by machine. Then the parts will be exactly alike; the part of one gun will fit into the same part of another gun. You can change the parts as you like, and they will always fit."

Nearly a century later Ford said: "Let us make all engine cylinders *exactly* the same size — all pistons, all bolts, all nuts, all axles, all wheels, rims, and tires. Let us turn them out by the thousands; perhaps later by the millions."

This is what Ford did, and because of it he could cut the cost of an automobile down to one fourth of what it had been.

As you know, other improvements came in the making of steel as well as the making of tools and machines. By 1910 the steel companies were selling very strong steel. The tool and machine companies were selling clever machines to make machines. These helped Ford to do everything on a big scale. By the 1920's the Ford Company was making an automobile complete, from the raw iron ore to the painted car, in two days!

The Invention of the Rubber Tire

But the automobile needed more than a good engine to make it a success. At first the tires of the wheels were of hard rubber, and they bumped along the roads. It was impossible to travel with comfort or safety at a rate much over ten miles an hour.

Then Michelin, a French manufacturer of rubber, got the idea of making a rubber tube, filling it with air, and using this as a tire for automobiles. He suggested it to some drivers who were to take part in a race in France. But the automobile-racers were not interested. They were all working as hard as possible to improve the engines of their automobiles. No car could run on four cushions of air, anyway, thought they.

Then Michelin built a car himself and equipped it with air-filled tires. At first the experiment was a failure. In fact, several of his experiments were failures; but, with each one, there was some improvement. Finally Michelin was able to convince the French automobile manufacturers that air-filled tires were really much better than those of hard rubber. Since that time they have been so greatly improved that today no passenger automobile is run without them. They have made the automobile one of the world's easiest means of transportation.

Automobiles Also Depended upon Good Roads

As you know, the motor car was born into a world of narrow dirt roads. It is true that macadam roads

had already been built in the northeastern part of our country and around the larger cities and towns. In some of the cities there were concrete or cement roads; but, for the most part, the city pavements were of cobblestones, which lasted a long time but had a very bumpy surface. Sometimes streets were paved with wooden blocks, which are not very durable.

What a difference today! Every city of any size in the country has smooth streets. Cement highways stretch even across the mountains and the plains. There are now three million miles of improved roadway in the United States. Within the short life of the automobile, which is now about 40 years, more than half the roads have been covered with good surfaces. Even the country roads which have not been paved are kept in much better condition than in earlier days, because people with automobiles demand it.

One of the best things that the automobile has done for countries of the Western World is to bring about the building of good roads. The United States now spends more than a billion dollars a year on road improvement, and other modern countries also spend large amounts. This is money well spent, too, because good roads not only increase our safety and our comfort in traveling but also bind our people together.

Ways of Living Have Been Changed by the Automobile

In the "good old days" — not so long ago for most of your parents — it was a rare experience to take a trip ten or twenty miles away from home.

But today, as you stand on the side of any road near any small town or a city, especially during the leisure hours of the day, automobile after automobile passes by. In the United States we think nothing of a trip of 200 miles in a day or even in a half day. In the evening we run over to the next city after dinner to call upon relatives or to go to the "movies." Thousands of our people live outside of towns and travel in automobiles from their homes to their work in the city. Indeed, chiefly because of the automobile, Americans have become the greatest travelers in the world.

Not only do Americans travel in their own automobiles; they use public motorbusses as well. In the spring of 1922 the people living along the road from Oakland to Los Angeles, California, noticed a large, well-furnished white bus passing their homes twice each day. Soon they began to wonder and ask questions about it. They learned that a bus company was making trial trips between the two cities in order to learn how much it would cost them to start a bus service. Within a very short time after those trips the motorbus was being used all over the United States.

The motorbus and the motor truck have solved the transportation problem for many of our communities. Thousands of small towns and villages are not connected by railroad lines. They have no other means of transportation to other parts of the state or country than busses.

The latest thing in bus travel is the service across the continent from one coast to the other and from Canada

to Mexico. Even sleeping-car busses run between our cities. Thus our way of travel and transportation have been greatly changed by this new vehicle.

The farmer's life has also been changed in many ways by the motorcar. No longer does he lead a lonely and separate life. Twenty miles used to mean a day's journey; now, in the motorcar, it is less than an hour's drive. The farmer goes into town easily whenever he wishes to buy supplies, to do business, to go to the movies, or just to "see the folks." Furthermore, good roads and trucks have made it possible for fresh farm crops to be taken each day to market in cities even 100 miles away. Hence land that was not worth cultivating because it was too far from the railroad has now become valuable.

The automobile has also helped to give country children a better education. One hundred years ago the pupils walked to school or rode on horseback. Each little village had to have its own little school, for the pupils could not travel ten or fifteen miles each way every day. It was hard to get good teachers, for they were poorly paid. Today the school bus makes its daily trips through the back roads as well as the main highways of the township and brings the children rapidly and easily to big central schools which are better in every way.

A Book You Would Like To Read

Lent, H. B. Wide Road Ahead! The Macmillan Company, New York. Tells how an automobile is made.

CHAPTER XX

From Rafts to Ocean Liners

IT IS interesting to remember that during the very years that the peoples of the earth were "scratching their heads" to invent better and quicker ways of traveling on land, they were also trying to find better ways of going about on the rivers and lakes and oceans. The story of ships moves right along with the story of wagons and trains, automobiles and airplanes. And it begins far, far back — even farther back than the story of wheels.

"What a long time it took people to invent things," perhaps you are saying to yourself as you study the pictures of figure 165. It took 15,000 years, perhaps 25,000 or more! Yes; but think of the hundreds of years, perhaps thousands, before that when wandering families or tribes were completely unable to travel on the water.

We can imagine that as these wanderers moved about, hunting for food and shelter, they would come now and then to a wide river or a broad lake. The peoples of Africa must have come to the banks of the river Nile or Congo or to the shores of Lake Victoria. So, indeed, the tribesmen of Europe came perhaps upon the river Danube or the Rhine or the Volga, or the Mediterranean or the Baltic Sea. Can you imagine the

feelings of the people of Asia as they reached the Indus or Ganges in India, or the Yangtse or the Yellow River in China?

And what must have been their astonishment when they came to the shores of a sea or an ocean! Did they look out as far as their sharp eyes could see and wonder if they could ever cross that wide stretch of water? Did they settle down and build houses on the coast and gradually learn how to travel on the water? We do not know.

Perhaps they saw that some things would float and that others would sink. Perhaps they discovered that a tree would hold up a man in the water. Sooner or later these wandering nature peoples must have learned that by sitting on a big log and kicking with their feet or pushing with a branch of a tree they could float and move themselves through the water. Such a log may have been the first boat (figure 154)!

Rafts May Have Been the First Boats

Finding that a log would carry a man, early peoples very likely tried tying several logs or poles together to make a raft. The scientists who have dug up the relics of early people say: "The raft is the first real boat made by man! We have found drawings on the stones in Egyptian graves of 6000 years ago which show that the people who lived around the Nile River at that time must have used rafts."

Of course the rafts could scarcely be called boats, for they were just reed poles tied together. Sometimes



Harold Sichel

FIG. 154. A log may have been man's first boat, and his own arms his first oars

bundles of reeds were built up a little on the sides to keep the waves from washing in.

The Assyrians who lived along the upper part of the Euphrates River used such rafts to send things down to the busy city of Babylon below. The loaded rafts would float slowly along with the current of the river. When the rafts reached Babylon the goods were unloaded and the rafts were sold. Then the rivermen walked back to their homes up the river. They could not use their rafts because they had no way to propel them up the stream against the current.

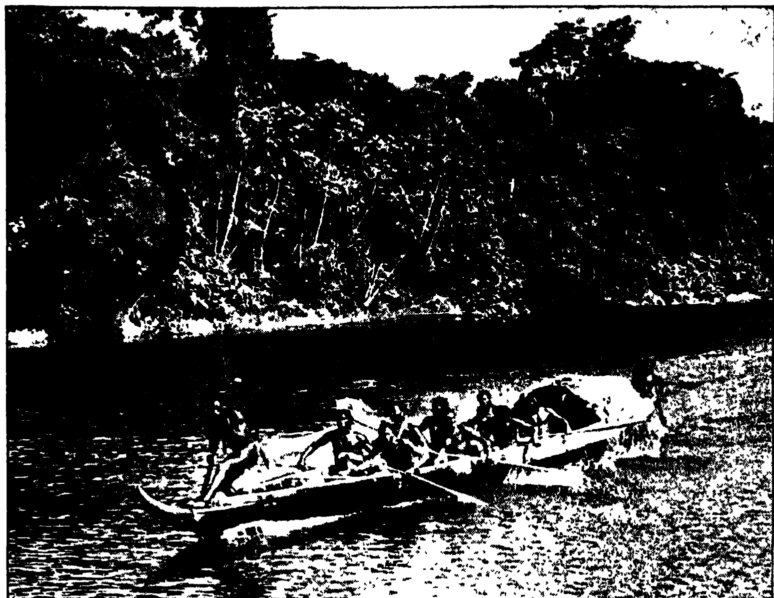
People Found Out How To Make Canoes and How To Use Paddles

Have you ever ridden on a lake or a river in a canoe? If you have, you know how lightly it floats on the water. With a beautifully shaped paddle one can glide swiftly along.

No doubt the peoples of several thousand years ago did not make canoes so well as we do today. It may be that the first ones were merely hollowed out of logs. There are tribes living today that still make canoes that way. We call such a canoe a "dugout." A tree is cut down and made into a log from 15 to 30 feet long. Then the wood inside is hollowed out by axes and whatever other tools the people have. It is likely that before people had good cutting tools they burned out the inside of the log. Figure 155 is a picture of a dugout.

The next step in canoe-making was very important. Reeds and twigs were braided, or laced together to form a frame. Over this frame the bark of trees or the skins of animals were fastened to make a covering. Even clay, which hardened into a baked surface, was used. Sometimes animal skins were sewed into a bag, blown up with air, and fastened to the canoe. These helped to keep it afloat.

With canoes and paddles people could travel upstream as well as downstream, out on lakes and other deep waters. By making the canoes long many paddlers could work at once. The picture of figure 155 shows



© William La Varre

Fig. 155. Poling and paddling a native dugout canoe on the Surinam River, Dutch Guiana

a long war canoe of some nature peoples. With their paddles swinging in deep, long strokes, and a singsong call to help the paddlers move together, such a crew can send their canoe along at a fine speed.

Those of you who have been in a canoe know that it has one great weakness: it tips over easily, dumping everything and everybody out into the water. It lacks a "keel" along its bottom to keep it balanced. For thousands of years no one thought of the keel. But "sooner or later," as we say, somebody thought up the outrigger to help balance the canoe. Poles were stuck

out from the side and fastened to a thin log which lay on the water. This helped to keep the canoe upright.

A whole book could be written about the boats of some of the simple peoples of today who use some kind of raft or canoe. Do you remember some of them from *Nature Peoples*? The Eskimo girls starting out in their long, thin kayaks? Or the Papuans, in their outrigger canoes? Or the Bakhtiari crossing a river on blown-up goatskins? Isn't it a little surprising to think that even today, while some peoples are building such ocean liners as the *Queen Mary* or the *Normandie,* there are thousands of tribes whose transportation is like that of the nature peoples several thousand years ago?

The Next Step: Large Ships of Timber

What happened to boat-making during the next thousand years or so we cannot be sure, but by the time of the building of the pyramids, 5000 years ago, the Egyptians were constructing large boats of cut timbers. We know that, because scientists have found many paintings of such boats on the stone walls of rulers' palaces, in tombs, and on clay pots and vases. These tell us that boats nearly 100 feet long were being used at that time. They went up and down the Nile River and out into the Mediterranean Sea and the Red Sea. One painting shows a single ship carrying a huge block of stone over 100 feet long. The stone had been cut from a quarry far up the Nile, brought down to the king's leading city, and set up as a monument. That boat must have been 300 feet long.



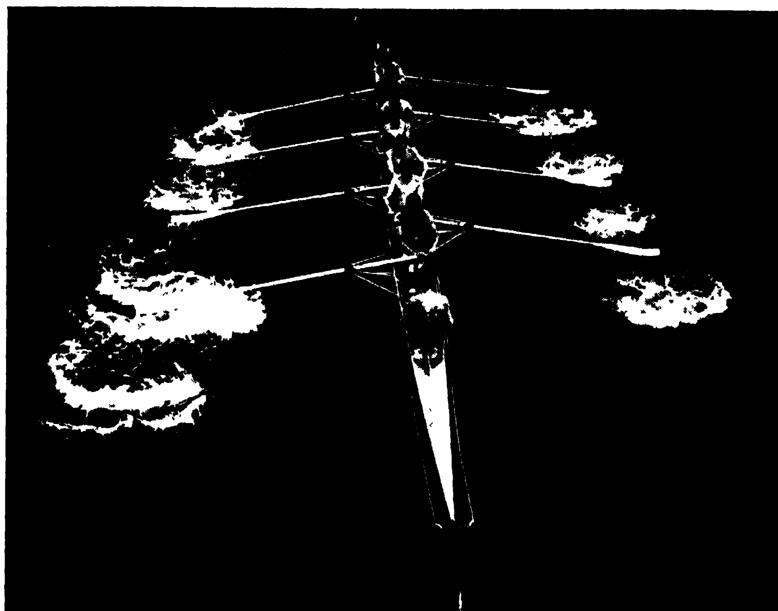
Ewing Galloway

FIG. 156. Can you tell what it means to paddle a canoe, as the boys are doing above?

Men Learned How To Row Those Ships

For a long time the Egyptians used paddles to make these larger ships go, but later some inventors got the idea of using oars.

What is the difference between *rowing* a boat and *paddling* a canoe? If you do not know, you can find out by studying figures 156 and 157. Notice how the canoe works. The paddlers sit near the back and the front of the canoe and face the front. They swing their paddles along the side of the canoe and pull the water toward them. This moves the canoe forward.



Ewing Galloway

FIG. 157. Can you now tell the difference between paddling and rowing?

Now study the men in the racing shell. They are rowing. Each sits on a seat in the middle of the boat and faces the back. Each has an oar resting in a support on the side of the boat. The rowers first lean forward and push the oars back into the water. Then they pull the oars through the water. Since the oars are fastened to the side of the boat, it must move. Back and forth they pull and push the oars, and on goes the boat through the water.

That is the idea that makes it possible to row a boat. It is simple enough, of course, after one learns

it, but it must have been a very hard idea to discover, for men did not do it until a few thousand years ago.

Now think of that Egyptian boat perhaps 300 feet long that you read about on page 351. Think that not one man would be rowing, but certainly 100 men, perhaps 200 or 300. For a long, long time they were the power that made boats go. The muscles of men's backs and arms and legs pulled the great ships through the water. Sitting in long lines, one man behind another, they pushed and pulled. Above them, on a platform, a leader pounded out the beat on a drum. Up and down the Nile they carried their loads of stone and metals, food and timber, and other kinds of freight. How their backs and arms must have ached! How tired they must have been!

Using the Power in the Wind

How long the early peoples depended on the muscles of slaves to propel their ships, we do not know. But finally some thinking man hit upon a very wonderful idea. "There is power in the wind," said he. "Let us use it. Catch it and make it do the work of moving our ships."

We can hardly imagine how many experiments must have been made before men learned how to set up a mast in a boat and fasten some kind of "sail" to catch the wind. But after hundreds of years of trying, ships with sails were made.

With sailing ships the Egyptians became the first real traders and explorers of their time. Not only up

and down the Nile did they travel, but out across the Mediterranean Sea to the towns along the coast of what is now Syria. From the forests of that country they brought back shiploads of wood from giant trees. From the mountains they brought gold and silver, copper and tin and other metals.

Along the Red Sea they sailed to the famous land of Punt, which they told about in their stories. This we think must have been Ethiopia and Somaliland. From Punt their ships carried back to Egypt the ivory of elephants' tusks, lumber, metal, and many other things.

Farther and Farther Out upon the Seas

As time passed, the Egyptian traders went farther and farther out upon the seas, looking for gold and other valuable things. But they had not dared to face the dangers of the vast unknown waters which we now call the Indian Ocean. They noticed that every spring and summer the winds always blew out away from Africa and across the ocean. They noticed also that every autumn and winter the winds blew back the other way — from across the ocean toward them.

No doubt travelers on the sea wondered about this for a very long time. Perhaps some thinking men began to say: "Will not those spring winds take our boats out to whatever land is on the other side? And will not the autumn and winter winds bring us safely back home again?" Many must have thought and talked among themselves in this way.

Then one day some of the traders and sailors did more than talk. They put to sea with the spring winds. For weeks they sailed eastward across the unknown ocean. Then they came to land. There they stayed all summer, hunting for the metals and timber and other things that their king needed. In the autumn, just as they had thought, the wind changed. Then they put to sea again and set their course in the opposite direction from that over which they had come. They sailed and sailed. At last they came again to Africa. They were home once more.

We know from the story of India in *Peoples and Countries* what had happened. The spring monsoons had taken them northeastward across the Indian Ocean to the peninsula we call India. The autumn monsoon winds had brought them back.

How far out upon the oceans these brave Egyptian traders went we cannot be sure. Some of our scientists think they sailed as far as China and the islands of the Pacific Ocean.

The Phoenicians Become the Sea Travelers of Their Time

Among the peoples who lived at the same time and a little later than the Egyptians were the Phoenicians, about 1500 B.C. They learned about ships from the Egyptians and became the greatest traders and sea travelers of their day. Do you remember from *Peoples and Countries* how they traveled all along the north shore of Africa, trading with the people who were settled there? On, westward to Spain, they went. Out

through the opening between Europe and Africa, called then the "Pillars of Hercules" and now the Strait of Gibraltar, they sailed their little ships. North along the coast of Europe toward France and England and south along the coast of Africa they went.

A Voyage around Africa

We are told of a remarkable voyage that one of the little ships of the Phoenicians made. It started in 600 B.C. (2500 years ago) on the Red Sea near the Isthmus of Suez and sailed southward. Slowly it went and probably not far out of sight of the shore. Month after month the captain kept the ship headed south into those strange waters. Never before had any of their countrymen gone there, and we can imagine that the sailors grumbled about being so far from home. They no doubt wanted to turn back, but on went the ship.

A year passed. Then one day they noticed that the coast line turned westward. For several months more they followed it, stopping to go on shore and explore from time to time. More months went by.

Then what a surprise! In order to follow the coast they must turn north again! What great body of land was this whose shore they were skirting? Do you know? They were at the southern tip of Africa. They had sailed along the east coast of Africa, rounded the Cape of Good Hope, and now were headed north on the west coast. For months more they traveled along. Then they noticed that the land was going east again. One

day they came to the Pillars of Hercules (Gibraltar) and soon they were in the Mediterranean Sea. Now they knew where they were — in home waters at last. Onward they sailed along the north coast of Africa until they came home to their trading city of Tyre in Phoenicia. They had been gone for three years!

Do you think that was a remarkable trip for those days? It seems so to us. Whether anybody else made that trip at that time, we do not know, but there is no record that anyone did until 2000 years later! It was not until 1498 A.D. that Vasco da Gama, a Portuguese captain, sailed south along the west coast, around the Cape of Good Hope, and on eastward into the Indian Ocean.

Hundreds of Years of Sailing History Passed

Although some improvements came in boatbuilding during the next 3000 years, there were no startling changes.

The picture of the *Santa Maria,* in which Christopher Columbus crossed the Atlantic in 1492 A.D., shows us the kinds of boats that were being used after 3000 more years of ship history. The *Santa Maria* was a little larger than the Phoenician trading ship. There were more sails and they were much larger and arranged better to catch and use the wind. But, after all, these were slight gains for 3000 years!

The boats were still small and really dangerous for ocean travel. They would carry very little freight and not many people. They were very slow. Columbus



M. Zeno Diemer

FIG. 158. In 1492 Columbus took three months to cross the Atlantic in this boat, the *Santa Maria*

took three months to cross the Atlantic. Most important of all, they still depended on the power of the wind. When the wind blew, they could move along a few miles in an hour; but when the wind stopped blowing, when there was a "calm," they stood still. Sometimes the calm lasted for weeks. Then the sailors were troubled, indeed.

As time passed, although ship captains were using the same power as did the Egyptians, they increased it many times. Instead of one mast they began to use two, then three, then four and five and even six! In-

stead of a flapping square sail that caught the wind only when the ship was going in the same direction as the wind, they used a sail that turned around on the mast and caught the wind, no matter in which direction it was blowing. And instead of one or two sails on a 20-foot mast, they used 150-foot masts and fastened ten, fifteen, and even twenty sails to them.

Then sailing men discovered that in order to carry so much canvas they had to enlarge the ship. The hulls became 30 or 40 or 50 feet wide, 200, 300, and more feet in length, and 20 or 30 feet deep.

The American Clipper Ship

Soon after 1840 American shipbuilders invented the finest kind of sailing vessel the world had ever seen. That was the "clipper ship" (figure 159). Nothing could compare with it for speed and beauty. The builders shaped the hull in long, graceful lines. Compare the slender lines of the clipper in figure 159 with the awkward, square-ended shape of Columbus's *Santa Maria* in figure 158. Compare the greater size of the clipper's sails.

The stories that have come down to us from 100 years ago tell of the wonderful speed with which these ships "clipped" their way through the high ocean waves. In a good wind they could go 15 miles an hour — 360 miles in a day. Before they came into use, sailing vessels took from four to six months to go from New York City to China. The clipper ship could do it in three months. One of the most famous of

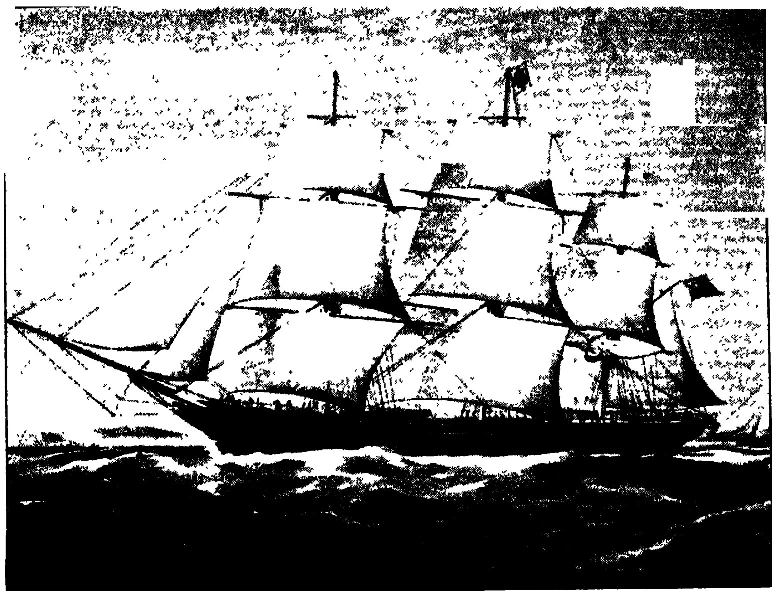


FIG. 159. How many days do you think it would take this clipper ship to cross the Atlantic?

the American clippers — *The Dreadnought,* built in a Massachusetts port in 1853 — crossed the Atlantic (from New York to Queenstown, Ireland) in less than 10 days. It had taken the *Santa Maria* 90 days.

Man never made better sailing ships than the clipper ship of 1850. But today, less than 100 years after the days of the clipper, sailing ships hardly count in water transportation. If you should travel the seven seas of the earth, you would see very few of them. Of course there would be small boats near the land. Most

of these would be fishing boats. You find those in and out of every harbor of the world, with the fishermen going out to catch their store of fish and coming back to port to sell it to the fish markets.

Now and then, as you crossed an ocean in a swift liner, you might pass a large sailing ship, its tall masts straining under wind-pulling sails. You would crowd up to the rail of your ship and look at the beautiful sight. "A tramp ship," someone would say. "A sail freighter going from port to port to pick up what goods it can carry. Not very many of them left! Steamships or motor ships, like ours, put them out of business."

So the conversation might go as you looked rather sadly at all that is left of the brave days of sailing the ocean. Those ships were beautiful, and in a high wind they were mighty fine transportation indeed; but when there was no wind, the great, beautiful things were not very useful to men. So the sailing ship had to go! Another kind of ship was invented to take its place — a ship that did not depend on nature's gift of wind power.

Boats Run by Steam Power

Has it occurred to you that again and again in the story of transportation *power* was the important thing? When man invented the paddle he got more power. When he made sails he got more power. As the sails on his boats became bigger and he used more of them he got still more power.

But, as you know, it was not until men had invented engines that the really startling changes in power took

place. And it was not until they had thought of attaching these engines to wheels that transportation as we know it today became possible. When men discovered that there is power in steam and that steam power could be used to move boats, a new kind of ship was possible. And, naturally, it was called the steamboat.

The steamboat has come to be considered such an important invention that several countries claim the honor of having made the first really workable one.

Germany claims the honor because of Papin, the same man who first hit upon the idea of moving pistons with steam. Papin made a steam pump and actually turned the paddles of a water wheel fastened to a boat. That was in 1707.

Do you think that Papin's little steamboat was received with excitement and enthusiasm? No, indeed! Papin had the same experience that almost every inventor has had. Those who ran the government would not help him. They would not even allow him to use his boat on the river. But it was the river boatmen who objected most. They saw that they might lose money if Papin's engine boat was allowed to stay; so a mob of them went to the river and smashed the boat.

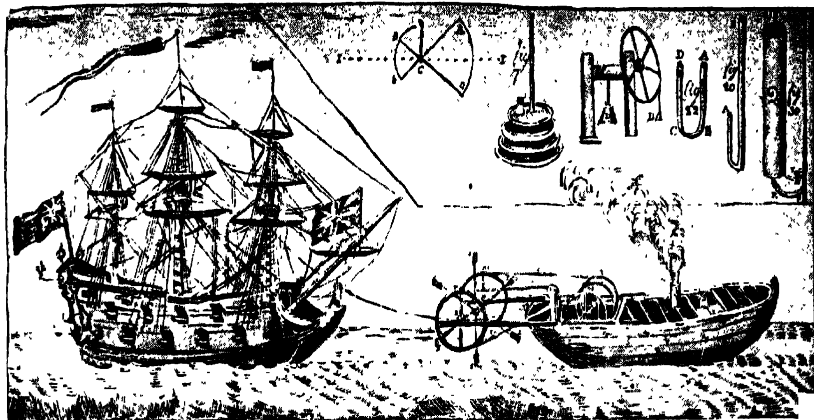
England has several inventors who claim the honor. That perhaps was to be expected; for in the 1700's a number of Newcomen steam pumps were used and were much talked about among people who were interested in such things. In 1736 Jonathan Hulls thought of a way to use a small Newcomen engine to drive the

paddle wheels of a boat. Figure 160 is a copy of a drawing that he made for his first boat. It shows that he planned to use it as a tugboat to pull large sailboats in and out of harbors. But we can find no proof that Mr. Hulls ever built such a boat; he merely drew a plan and wrote about it and secured a patent from the government.

The French also tried to be the first to drive boats with steam. They even offered prizes for the best plans. During the 1760's and 1770's, at the very time James Watt was making the steam engine, several Frenchmen tried to propel boats with steam power. Most of them failed; but the Marquis de Jouffroy succeeded at Lyon, on the river Saône, in 1783. His boat was 150 feet long; it had paddle wheels 14 feet in diameter; and it *did* move through the water! Soon people began to speak of his success. But to his astonishment the government of France would not give him the right to use his boat on the rivers! So he did what Cugnot had done about his steam cart: he just quit.

Americans May Well Claim the Honor

In the case of the steamboat we think that the United States can rightfully claim a share of the honor. Several Americans helped to make it possible. The first was William Henry of Lancaster, Pennsylvania. He was in England in 1760, and there he heard much talk about steam engines. In 1763, before many people knew that Watt had made a really practical engine, Henry built one himself and tried to run a boat with it



Smithsonian Institution

FIG. 160. This is the copy of a drawing which Jonathan Hulls made for a steamboat in 1736



Continental Insurance Company, N.Y.

FIG. 161. This is how an artist imagined the trial of John Fitch's steamboat propelled by oars might have looked

on a near-by river. But he had not judged correctly about its weight, and the engine was so heavy that his boat sank. But Henry was not discouraged. He went on studying out new plans and, for the rest of his life, talked with many people about them.

Several young men who were interested in steamboats heard about his experiments. The first of these to try to build a steamboat was James Rumsey. Rumsey began his work in 1774, and it is said that twelve years later his boat actually steamed up the Potomac River at a speed of four miles an hour. History tells us that General George Washington saw him do it.

In 1787 Virginia gave Rumsey a patent, and he went about trying to interest people and raise money to help him build steamboats. For six years he failed to get the help that he needed. Then he tried England; but while he was in the midst of building a boat, he died. Later this boat traveled on the Thames River near London, also at the rate of four miles an hour. Although Rumsey did not make a steamboat that was used in transporting people and goods, he is regarded as one of the real pioneers in its invention.

James Fitch: The First Really Successful Steamboat Inventor

But there was another young man to whom William Henry had spoken about his ideas. This was John Fitch, a Connecticut mechanic who had fought through several years of the Revolutionary War with George

Washington. Fitch seems to deserve the most credit for the steamboat. In 1785 he made a little model, and the next year he formed a company with Henry Voigt, a Pennsylvania-Dutch watchmaker. This was at the very time when Rumsey was running his first boat in Virginia.

No wonder people laughed at Fitch's boats; they *were* funny things. In one of them he tried oars, but the boat (see figure 161) shook so badly that Fitch gave it up and went back to paddle wheels. From then on, his story is one of the bravest in the history of invention. Year after year he stuck to his task. With their own hands he and Voigt built boat after boat, engine after engine. Remember that in the 1780's and 1790's men had not learned to make steel furnaces and tools that could be used in making the new engines and machines. So Fitch's engines and machinery fitted badly and ran badly, just as Watt's did during the same years; but he kept at it in spite of his troubles with tools and with men.

In May, 1787, a 45-foot boat was finished and sent through the water. Its speed was two or three miles per hour. Of course no one thought that was important; a man can walk as fast as that. In August, 1787, there was another trial at which the famous Benjamin Franklin was present. After watching the boat for a while, Franklin said that steam would never succeed; sails were better. Several of the states did grant Fitch patents for "steam navigation," but the members of the Congress of the new United States were too busy

making the Constitution, so they had no time to think of such an invention.

Still Fitch persevered. In 1788 a 60-foot boat with a bigger engine than the first turned a paddle wheel at one end of the boat and moved it four miles an hour. But even that speed was not startling.

Then on April 16, 1790, Fitch ran his third boat at seven miles an hour on the Delaware River. Success at last! Seven miles was fast enough, faster than any other kind of transportation! It was cheaper, too, for water travel was much cheaper than land travel. From June, 1790, Fitch's boat went up and down the Delaware River, steaming altogether several thousand miles before it was put out of use. The people of Philadelphia, Pennsylvania, and Trenton, New Jersey, and the little towns between had the first regular steamship service in the world.

In 1791 the United States government gave Fitch a patent, and he started to build a fourth boat. But even with his success, people in our country were not interested enough to invest money in steamboats. Fitch thought he would try the Europeans, so in 1793 he went to France to ask for the right to begin steam navigation there. He arrived in the midst of the French Revolution, so, of course, no one was interested in steamboats. He returned to the United States a poor man.

Finally Fitch went to live out in the new Western country — in Kentucky. In 1798 he died there, a sad and bitter man. Before he died he said, "The day will

come when some more powerful man will get fame and riches from my inventions, but no one will believe that poor John Fitch can do anything worthy of attention."

How true that was we shall see later.

British Inventors Succeed

While Fitch was having his troubles with engines and paddles in America, a mechanic named William Symmington was having similar ones in Scotland. Symmington spent most of the years of the 1780's trying to invent a steamboat. He also spent about $150,000 which belonged to a rich Scotch banker. By 1789 he had made a 60-foot boat that ran seven miles an hour, but then it broke down. That was the end of the banker's help.

For ten years Symmington tried to find another rich man who had money to burn or to sink in river boats. Finally Lord Dundas, who owned part of the Forth and Clyde Canal, decided that a steam tugboat might haul ships through the canal cheaper than horses and men could do it. He let Symmington try; and in 1801 the *Charlotte Dundas,* which was named for Lord Dundas's daughter, pulled two large ships all the way to Glasgow.

Next, the duke of Bridgewater, a member of the Canal Company, gave Symmington an order to build several more tugboats just like the *Charlotte Dundas.* Work was just about to begin when the duke died. Then the usual thing happened. The other canal-owners did not believe in new things and would not

go on with the work. But Symmington had proved that steamboats could be used to carry goods and people.

Oliver Evans Tries His Hand

Now our story takes us back to America again, and this time to look upon the last acts of the steamboat play. We must be sure to include Oliver Evans, a Philadelphia mechanic who knew something about engines. In 1804 he built a boat called a "dredge" to keep the Schuylkill River clear of mud. Nor was this just a boat. Evans put wheels under it and drove it through the streets of Philadelphia and on into the river. There it was, the first "amphibian," a vehicle that would work both on land and on water. Evans, using Latin, gave it an unusual name — *Oruktor Amphibolos.* Down the Schuylkill and into the Delaware it steamed — certainly a steam-driven boat, even if it was only a scow and a mud dredger.

Fulton, Inventor, and Livingston, Business Man, Succeed at Last

Meanwhile more people were becoming interested in steamboats. In 1798 Robert Livingston, a leader in the government of New York State, secured the right to run steamboats on all the rivers of New York State for fourteen years.

"That is," the other members of the government said, "if you can make a boat that will go four miles an hour!"

Livingston was not an inventor, and, of course, he could not make the boat. But just then President Thomas Jefferson sent him to France to take care of American affairs, and while he was spending some time in England he met Robert Fulton. Fulton, it seemed to Livingston, was just the man he had been looking for. We see now that it was not only clever inventors but also business men with money who would make steamboating a success.



Fig. 162. Robert Fulton, the portrait painter, who discovered how to propel a boat with a Watt steam engine

Robert Fulton was another of those young men who had talked to William Henry and had thought much about his ideas. As a boy of fourteen Fulton had played with toy paddle wheels, and as a young man he had worked a bit as a watchmaker. But he left that and went to England to study painting. Apparently he had not lost interest in steamboats; for after his meeting with Livingston both men became acquainted with the people who were working on them. The two Roberts then decided to make a steamboat themselves and went over to France to do it. Using

ideas that had probably come from both John Fitch and William Symmington, Fulton made the plans for two different boats. Livingston had them built in Paris. At the very moment that Evans was driving his clanking scow through the streets of Philadelphia, Fulton and Livingston were launching their ship on the waters of the Seine in France.

But the French were still not ready for steamboats, so Livingston and Fulton came back to America. They had a Watt engine sent over from England and built a large vessel 135 feet long. It was named the *Clermont* after Livingston's country home on the Hudson River.

In 1807 Fulton set out on the Hudson River. The people of New York and New Jersey laughed and called the boat "Fulton's Folly" (figure 163). But their jeers changed to cheers when they saw the *Clermont* shake, stir a bit, and then move steadily up the river. A few days later the boat ran the 150 miles from New York to Albany, upstream against the current, in 32 hours. The steamboat was now a success!

As you look at the pictures of the *Normandie* or the *Queen Mary*, those giant liners of today (figure 164), you can see how travel and transportation on the water have changed since 1807.

Books You Would Like To Read

ADAMS, PETER. Clipper Ships Done in Cork Models. E. P. Dutton & Co., Inc., New York. Histories of some of the most famous clipper ships, with directions for making simple models with cork, matches, and pins.

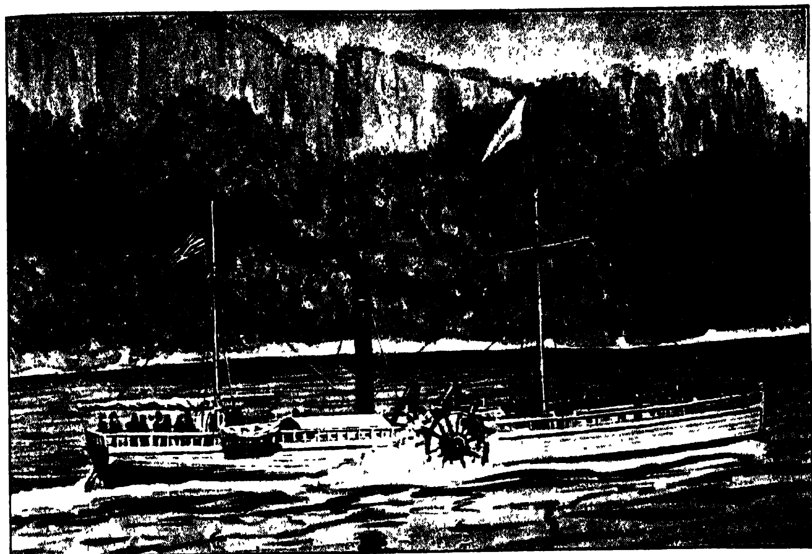
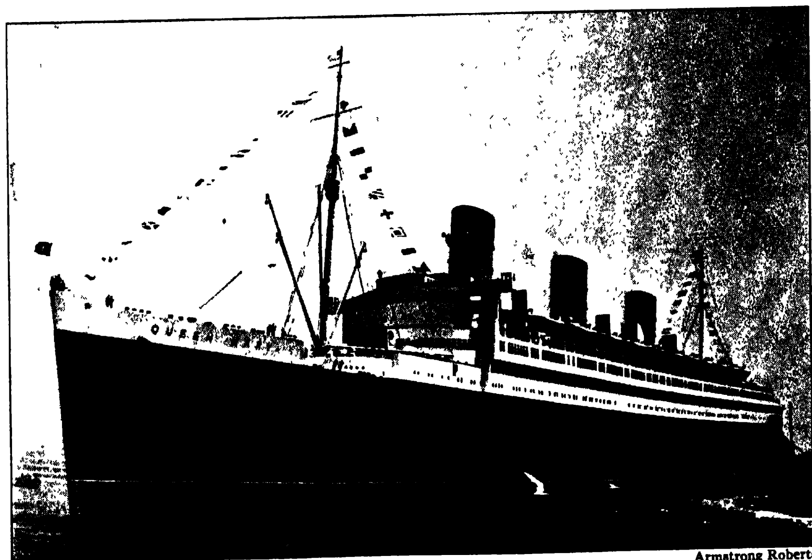


Fig. 163. Robert Fulton's first steamboat moving up the Hudson, 1807. The people laughed and called it "Fulton's Folly"



Armstrong Roberts

Fig. 164. One of the latest models in shipbuilding

ADAMS, PETER. Cork Ship Models and How to Make Them. E. P. Dutton & Co., Inc., New York. Simple directions for making historical models of ships.

BRIDGES, T. C. The Young Folk's Book of the Sea. Little, Brown & Company, Boston. Interesting sea lore, together with the story of commerce and social life that has developed upon and about the sea.

BUCKMAN, D. L. Old Steamboat Days on the Hudson River. Grafton Press. New York. Tales and reminiscences of the stirring times that followed the introduction of steam navigation.

D'AULAIRE, MRS. I. (M.), and D'AULAIRE, E. P. The Conquest of the Atlantic. The Viking Press, New York. Exciting adventures upon the Atlantic from the time the vikings crossed the Sea of Darkness until Lindbergh and Balbo flew through the air above it.

DUKELOW, MRS. J. H., and WEBSTER, H. H. The Ship Book. Houghton Mifflin Company, Boston. A history and description of ships and how they developed down through the ages.

HAWTHORNE, DANIEL. Ships of the Seven Seas. Garden City Publishing Company, Inc., Garden City, New York. A story of steam navigation.

HOLLAND, R. S. Historic Ships. Macrae-Smith-Company, Philadelphia. Tells about ships of different periods and countries.

LENT, H. B. Full Steam Ahead! The Macmillan Company, New York. Fascinating information and illustrations that tell of an ocean liner from bridge to engine room. Six days on an ocean liner.

STARBUCK, WILSON. Liners and Freighters. Thomas Nelson & Sons, Ltd., New York.

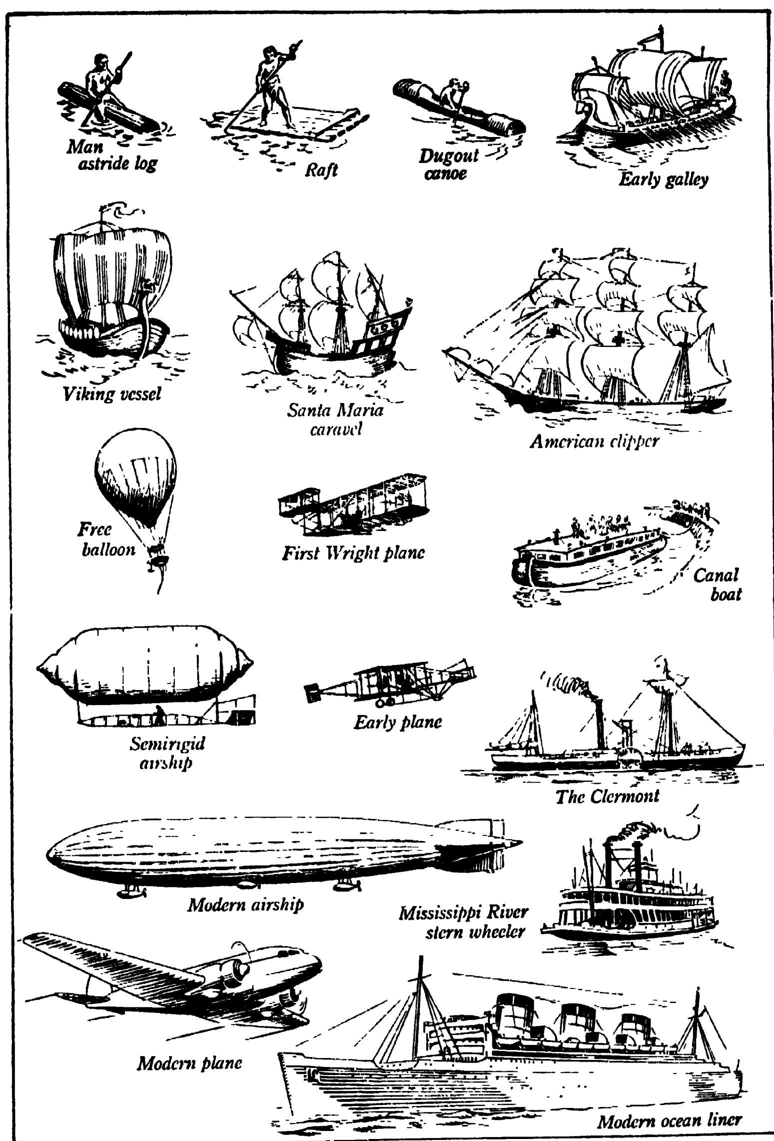


Fig. 165. Conquering the sea and the air

CHAPTER XXI

Learning To Fly

THE MEN of the Byrd Antarctic Expedition were near the end of a long day. They had been hauling supplies by dog sled from their ship to the camp, some distance away. Suddenly they were startled by the sound of an airplane overhead. Swiftly out of the sky it came, and Commander Byrd waved to his men as he passed over them. Sverre Strom, the giant Norwegian mate, looked first at the plane disappearing over the horizon and then at his tired dogs. He shook his head.

At the ship, later that night, Strom said to Byrd: "I stopped the dogs and watched you fly by, and then I said to myself, 'Here I am a thousand years behind the times.' Ja, a thousand years — sweating and pulling and doing in three hours what you do in ten minutes. It made me feel like an Eskimo." [1]

The airplane is, indeed, man's latest invention in travel and transportation. In it he can fly like a bird through the air at speeds that would have seemed impossible even to your grandfathers. And within their lifetime the airplane has been added to the automobile, the railroad, and the steamship as another way of carrying goods and people.

[1] *New York Times*, January 18, 1929.

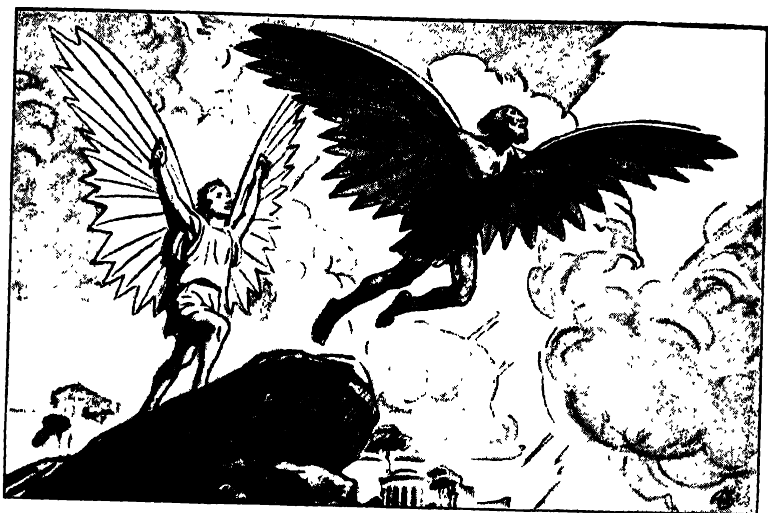


FIG. 166. Men have always dreamed of flying, but the Greeks thought that Icarus and Daedalus tried it

Men Have Always Dreamed of Flying

Stories that have come down to us from the earliest times show that people have always dreamed about flying. Among the Greeks there was the old tale of Icarus, who tried to fly by fastening wings to his body with wax. Unfortunately he flew too near the sun. The heat melted the wax, and he and his feathers tumbled to the earth.

There was a physician to a king of Scotland who also tried to fly with feathers. He chose eagle wings because the eagle, of all the birds of the earth, soars the highest. But when he put on his feathers and jumped from the castle walls, instead of rising like the

eagle he fell to the ground and broke his "thee-bone." In spite of the accident he still had faith in wings and explained his fall in this way: chicken feathers must have been mixed with those of the eagle; and since it is well known that the chicken prefers the earth to the air, these feathers had brought about his fall.

Besides stories that were "made up" about flying, early scholars spoke and wrote about how it could be done. Leonardo da Vinci (1452–1519), the famous Italian scientist and artist, even drew plans and made models of flying machines. A hundred years later Francis Bacon, a well-known English thinker, said he believed that men would conquer the air.

So through the centuries men dreamed and thought about flying. So far as we know, no one was able to do so, even for a very short distance, until the 1700's. You have heard those years mentioned many times in the story of invention, have you not? It was during that time that Watt and the others were working on their engines and machines. Men were also trying to make machines that would lift them from the ground and carry them through the air.

The First Step: Fire Balloons

In 1783 two brothers, Joseph and Étienne Montgolfier, were experimenting with balloons in France. Many times they had watched clouds floating in the sky, and one day the idea occurred to them that a bag could also be made to float if it could be filled with something as light as air. Clouds suggested

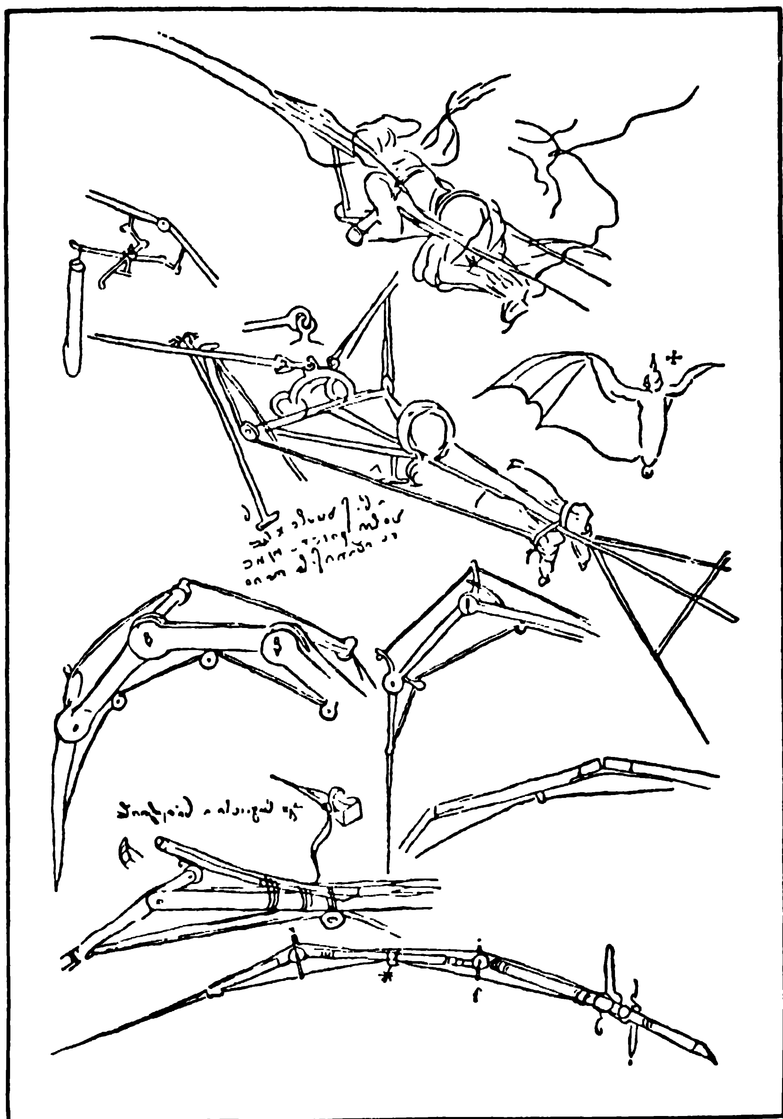


Fig. 167. Plans for a flying machine drawn by Leonardo da Vinci more than 450 years ago. Can you figure out some of the different parts?

smoke; so they took some paper and made a large bag with an opening at the bottom. Under the bag they built a little fire with straw. As the smoke rose, it filled the bag, and the bag began to rise. The brothers were very much excited and decided to go on with their experiments.

Next they made a large paper balloon 110 feet around and filled it the same way as before. They now discovered, however, that it was the heated air from their fire and not the smoke that lifted the balloon. They saw that as air gets hot, it becomes lighter than cold air and begins to rise.

The Montgolfier brothers were now ready to try their balloon before the public. At this first trial the balloon rose to the unexpected height of 6000 feet. As the air within it began to cool, the balloon gradually came down. You can imagine how much excitement there was at this success! The Montgolfier brothers were encouraged to build a larger one, and they did.

To their next balloon they fastened a basket and placed in it a sheep, a rooster, and a duck. The balloon rose, sailed gently along with the wind for about half a mile, and then descended in a forest. The animals were uninjured except for the rooster, which had been stepped on by the sheep!

The next step was to test the balloon with human passengers. A young Frenchman, Pilâtre de Rozier, stepped into the basket and was lifted to a height of 75 feet, the full length of the rope. Benjamin Franklin, who was in France at the time, saw the unusual event.



Robert Lawson

FIG. 168. Montgolfier's balloon with its passengers—the sheep, the rooster, and the duck

Later Rozier and another man went up in a balloon that was not tied, taking along with them some fuel for the fire. When they found themselves falling, they put on fuel; when they rose too high, they let out some of the hot air by pulling a cord which opened a hole in the bag. In this way they made a journey lasting about twenty-five minutes.

The Second Step: Gas Balloons

There was always the danger of balloons catching fire from the blazing straw. This danger led inventors to think of other things than heated air with which to fill their balloons. Hydrogen gas, which weighs only one fourteenth as much as air, was tried and it worked well. Bags were made of thin silk, covered with a varnish so that the gas could not escape through the cloth.

The first trial of this kind of balloon was made in a rainstorm. In spite of the rain the balloon rose to a height of 3000 feet, remained in the air three quarters of an hour, and came down in a field fifteen miles away. Farmers who were at work in the field were so frightened at this strange object from the sky that they tore it into shreds. To be sure that this would not happen to other experiments, the king himself had to send out an order that things coming down out of the clouds were on no account to be touched.

Gas balloons were improved rapidly, and in 1785 the first one set out from England across the English Channel to France. In it were Blanchard, a French

airman, and Doctor Jeffries, an American, who eleven years before had gone up in balloons from London to study the wind and weather.

Their balloon traveled with its load until halfway across the Channel. Then it descended so low that the men feared they would drop into the water. They threw out everything of weight — their food, the ropes, even most of their clothing. Luckily this made the balloon light enough so that it rose again. At last they were over the French shore. There they opened a valve to allow the gas in the bag to escape slowly, and landed with cheers and shouts from the crowds that had watched them descend.

At the time that these experiments were being made in France, others were also being made in the United States. In Philadelphia people were trying different gases with which to fill balloons. Shortly after his trip across the English Channel, Blanchard visited our country. While in Philadelphia he made the first air voyage in the United States. Many well-known people were present to watch him, among them General George Washington.

As balloons were improved, people began to make longer and longer journeys. In 1836 the "Great Balloon of Nassau," carrying twelve passengers, drifted from England over into Germany, traveling a distance of 500 miles. Part of the journey was made at night, without lights and with no way of guiding the ship. The passengers could only guess whether land or water, farms or cities, lay below them.

The Third Step: Airships Driven by Engines

Just as ships depended upon the winds to drive them, so balloons were at the mercy of the winds. Besides, it was almost impossible to steer them. People tried to use sails, oars, even paddle wheels, but with little success.

By the middle of the 1800's steam engines were being used to propel wagons on roads, locomotives on rails, and boats in water. So airmen said, "Why not try engines in balloons?" And many inventors did try to make airships that were driven by steam.

In 1852 Henri Giffard, a French engineer, designed and built such a balloon, shaped somewhat like our airships of today. In the long car which hung under the balloon was placed a small steam engine that Giffard had made specially for his airship. The experiment was a success, for the balloon reached a speed of four miles an hour. This was the first airship which could be steered.

When airmen saw that airships, or "dirigibles," as they are now called, could be driven by steam, they began to improve them. This happened very slowly, however, because steam engines were so heavy. Some other fuel must be found, said they, which will be light and yet powerful. And find it they did, in the new gas engines that were being invented and put into the new "gasoline buggy," or automobile. In 1898 Alberto Santos-Dumont, a Brazilian, succeeded in putting a gas motor into an airship and making it go. The gas



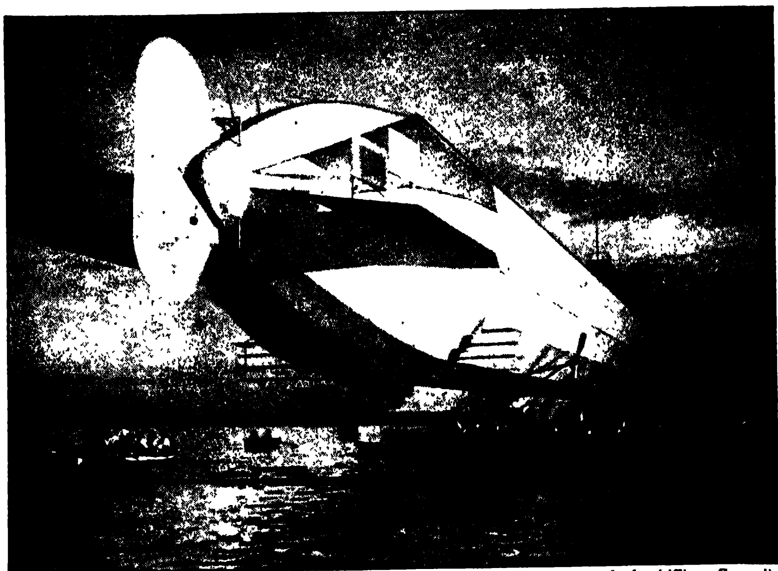
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FIG. 169. Santos-Dumont's airship, the first to be driven by a gas engine

engine was not only lighter than the steam engine; it was also safer, for there was less danger of explosion from the hydrogen gas in the balloon.

Other improvements then came, one of these being in the bag of the balloon itself. The bag was now made up of several small sections, each being separated from the others. Even if a leak occurred in one section, the gas in the others would keep the bag up in the air.

In Germany, about 1900, more experiments were being made in airships by Count Ferdinand von Zeppelin. In place of the cloth bag, he built a frame of aluminum to hold the separate bags of gas. Airships



Luftschiffbau Zeppelin

Fig. 170. One of the huge Zeppelins built in Germany in 1909

made with these metal frames were much stronger and could be propelled and steered more easily. This is the kind of airship most widely used for passengers today.

During the World War, Germany built about 100 airships of several different types. After the war she began to build airships for other countries. The *Los Angeles* is one that was built for the United States navy. It crossed from Germany to Lakehurst, New Jersey, in 1924 — over 5000 miles — in 81 hours, going on an average of 60 miles an hour.

Within the past few years another gas — helium — has been discovered. This is found to be safer than

hydrogen for airships, because it will not burn. It is very expensive, however, and the United States is the only country known at present to have a fairly large supply of it.

Another Kind of Air Transportation: Airplanes

Had you ever thought that there was a difference between airships and airplanes?

Airships are well named, for they float in the air as ships float in the water. Even the largest ones with metal frames must be lighter than air, since they depend upon lightness to keep them up.

Airplanes, however, are heavier than air. Perhaps you are asking, "How can anything that is heavier than air be kept up?"

You can experiment for yourself with this idea by "sailing" a small piece of cardboard. If it goes *fast* enough, it will stay in the air. Anything moved through the air fast enough will stay up. So you see that with machines which are heavier than air, *speed* is the thing that is necessary. And it was because men had not made engines with enough speed that the invention of the airplane was held back for so long.

The First Airplanes: Gliders

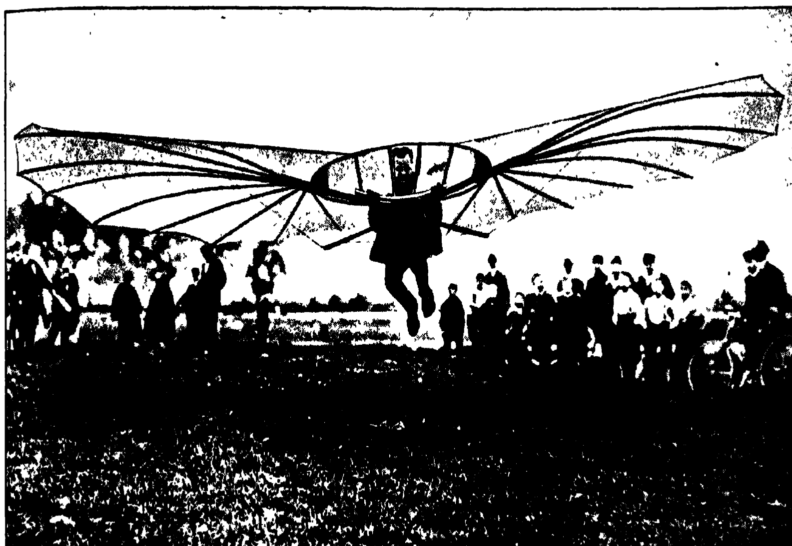
The first airplanes were gliders, which were fastened to the body of the flyer with straps. They were made in many shapes. Some had queer wings like those of a bat; others had things sticking out in different directions to catch the wind. There was no engine, of course.

When the flyer wished to set the glider going, he ran from the top of a hill. With a strong wind blowing, he might travel for 100 feet. With little wind — well, you can imagine what happened.

Men watched birds and studied how they flew. Then they built gliders, using the ideas which they had discovered. A French sailor who had some success with gliders built one with wings like those of the giant bird the albatross.

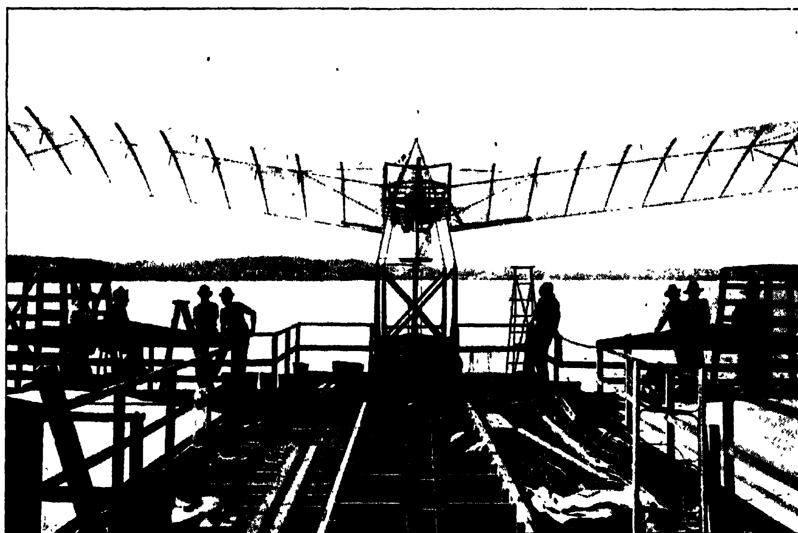
One of the most famous of the first experimenters was a German, Otto Lilienthal (figure 171). Lilienthal studied the birds and used his knowledge of them in making gliders. He made some very successful flights in 1891. One reason for his success was that he learned how to control his planes in the wind. Gliders were difficult to steer and hard to keep level when the wind came with more force on one side than on the other. Lilienthal became very skillful in using the weight of his body to keep his balance. As the wind caught the surface of the glider, he would turn and twist, moving his weight now to this side, now to that.

For years Lilienthal worked. With each flight he discovered new things about the winds. Then he would improve his gliders and try longer flights. One day while testing something for steering, he lost control, fell, and was killed. It is believed that if he had lived a little longer he would have tried engines and might have succeeded in making the first airplane. Lilienthal, however, had done the first difficult task: he had learned how to control his planes in the wind.



Aero Digest

Fig. 171. Otto Lilienthal in one of his gliders



Keystone

Fig. 172. The flying machine which brought to Samuel P. Langley the title "father of aviation"

Gliders with Engines

Fifty years before Lilienthal's success with gliders a few inventors had tried to put small steam engines in flying machines. In 1840 an Englishman named Henson designed a model of a flying "steam carriage." This had wide wings and wheels that looked somewhat like those of our airplanes today. People were not very much interested in Henson's ideas, however, and he was not able to go on with his experiments.

Another Englishman, Charles A. Parsons, made a model in 1848. This one had a steam engine and a boiler. Although the steam engine was really too heavy for the airplane, Parsons's model did stay in the air for more than 100 yards. As in the case of the airship, however, it was not until the gas engine had been invented that the airplane was really possible.

The inventor Samuel P. Langley was the most important of the men who made the early experiments. Langley was helped by men in the United States War Department, for they saw that airplanes might be useful in time of war. He received from the War Department money with which to build a strong, man-carrying airplane that was to be moved by an engine. He and his assistant set to work and made a special gas engine which was small and light. They put an automobile steering wheel into the plane; this made it easier to manage.

By the autumn of 1903 everything was ready for a test flight. Two trials were made, with Langley's

assistant operating the machine. In each case something went wrong, and the machine was unable to rise. Disappointed by this failure, Langley gave up his experiments. He died soon afterward. But in spite of the fact that he could not get his machine to work, he is remembered as the "father of aviation."

December 17, 1903: Success at Last!

Shortly after Langley had failed with his machine, two brothers, Orville and Wilbur Wright, made the first flight in a man-carrying airplane. For 59 seconds, an undreamed-of length of time, their heavier-than-air machine stayed off the ground.

The Wright brothers had, for some time before, been preparing for their flight. They had been experimenting with gliders, trying to find new things about the wind. They not only read the books about wind and weather but they also made models of possible machines. They also designed a gas engine of the right size and power.

Following their first flight on December 17, 1903, the Wright brothers continued their careful experiments, improving their engines and the various parts of their machine. So well did they learn to make airplanes that even today the Wright engines are widely used. The plane in which Colonel Charles A. Lindbergh flew to Paris in 1927 had a Wright motor in it.

By 1908 Wright airplanes were remaining in the air for more than an hour. Now European countries became interested in aviation. The Wrights traveled



Fig. 173. Orville Wright holding a model of the Wright brothers' first airplane and a model of the latest in fast military planes

in various European countries, introducing and showing their plane. The French inventors, especially, were greatly encouraged by the visits which the brothers made to a number of French cities.

In 1906 Santos-Dumont, who had been so successful in building dirigibles, made the first European airplane trip. In 1909 a Frenchman, Louis Bleriot, crossed the English Channel in an airplane. This was regarded as a great event. Most people had doubted that an airplane could cross the Channel, even though a balloon had already done so.

In 1910 came the first successful hydroplane, which was invented by Glenn Curtiss. *Hydro* means "water."

So you can understand what kind of plane Curtiss's was. It had a boatlike bottom instead of wheels. It would land on water or take off from it. This idea led later inventors to plan airplanes which could land either on water or on land. Airplanes of this kind are called "amphibian planes."

In spite of the success of inventors, most people in the United States were slow to take up aviation. Even in 1911, eight years after the Wrights had proved the value of their machine, there were in the United States only 25 air pilots with licenses. At the same time France had 383 aviators. Indeed, all the large European countries had more pilots than the United States. The airplane was still regarded here largely as a new way of entertaining people.

The World War Brought Many Airplanes

Then came the World War (1914–1918), and aviation took its place as one of the four important means of transportation. When the war broke out, none of the chief countries had many airplanes; when it ended, there were tens of thousands of planes and trained pilots.

Our country entered the World War in 1917, after the countries of Europe had been fighting for three years. At that time the United States had plans to make 3000 airplanes. The plans were changed, and within eighteen months 15,000 planes had been built.

The motors of these war planes had all their parts made in *standard* shapes and sizes. You remember

what was said about the great advantage of that in the chapter on machines. The parts could be made by the thousands, or even by the millions, and could be replaced easily if they were broken.

The World War did something else for aviation. It gave training to a very large number of intelligent young men, and when the war closed, there were thousands of expert airplane pilots. While many of these went later into the air-mail service, others were employed in carrying people and freight to all parts of our country.

Airways and Landing Fields Today

Do you suppose that airplanes can fly anywhere and at all times without routes to follow? No, indeed. They need well-marked paths and special landing places, just as do other means of transportation.

Especially is this true for night-flying. If we follow a night plane we shall see it leave a field where many lights are flooding through the darkness. Lights along the runway help the pilot to take off from the course. Beacon lights point the way toward his next goal. As he glides over the land he feels quite safe, for he knows that there are fields along the way where he can land if he is forced down.

For the most part the route has also been carefully chosen. Maps guide him over the level country, where landing would not be difficult. When the mountains are reached, there are more landing places, and the guiding lights are nearer together. Here some of the

beacons are so powerful that their beams can be seen for 150 miles. In fact, the whole route from coast to coast is lighted, so that night-flying can be done safely.

If you look at map 5 you will see that airways connect the cities of our country just as do the waterways and the roadways and the railways. And everywhere along the way are landing fields, the stations of the airplane. At first landing fields were placed at a distance from large cities, for this seemed safer; but now they are being built either in the cities or near them. Business people who travel to any city by airplane naturally want to get there with the least possible delay. Many large cities have several landing fields just as they have several railroad stations.

Besides lighting the aviator on his way, the stations give him directions by radio. Each plane has a radio compass, an instrument which shows the signals that are sent out by radio from the stations. These signals show the pilot whether he is on his course or whether he is steering too far to the right or the left of it.

The stations also give the latest weather reports. These help the aviator to avoid storms by changing the direction in which his airplane is flying. Many stations have huge lighted arrows, like weather vanes, showing which way the wind is blowing. The airplane and the airship still depend on wind and weather just as the sailing ships at sea do, and to fly in the air requires much the same knowledge as running ships on the ocean.

Today people ride in an airplane as they would in an automobile, and for many of the same reasons. In

a recent year there were 12,000 miles of air routes in the United States, and in that year the total number of landing fields was 3806.

Books You Would Like To Read

CHARNLEY, M. V. The Boys' Life of the Wright Brothers. Harper & Brothers, New York. Telling how their experiments helped the Wright brothers in the science of flying.

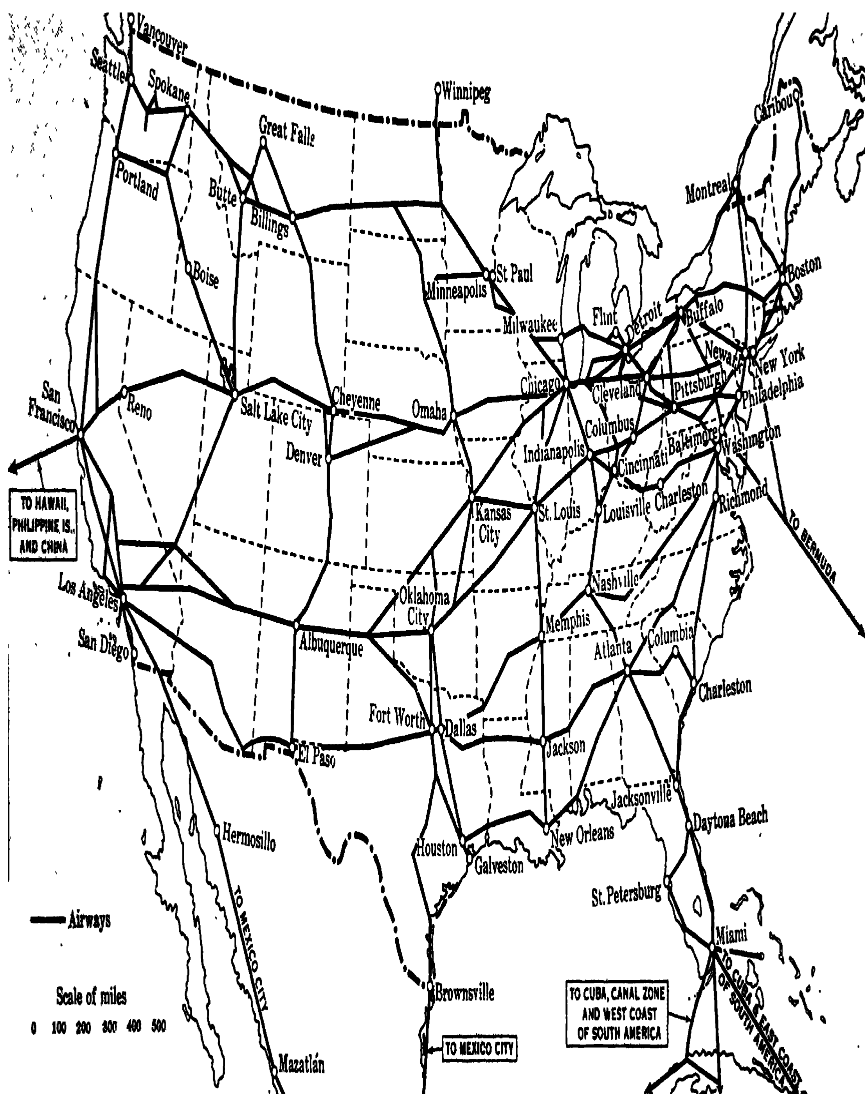
FLOHERTY, J. J. 'Board the Airliner. Doubleday, Doran & Company, Inc., Garden City, New York. A camera trip with the transport planes.

FRASER, CHELSEA. The Model Aircraft Builder. Thomas Y. Crowell Company, New York. An interesting account of training for flying and also of making a model airplane and of equipment for flying fields.

JONES, PAUL. An Alphabet of Aviation. Macrae-Smith-Company, Philadelphia. Interesting information about basic types and parts of aeroplanes, including automatic pilot, radio telephone, and air beacon.

MCNAMARA, J. F. Playing Airplane. The Macmillan Company, New York. Thrilling imaginary trip among the clouds in an airplane. Other "make believe" adventures.

PRYOR, W. C., and PRYOR, H. S. The Dirigible Book. Harcourt, Brace and Company, Inc., New York. A story about two children on a real trip on a dirigible. Many photographs taken of the *Hindenburg*.



MAP 5. The airways of the United States

CHAPTER XXII

Messages before the Days of Electricity

Sending Messages Face to Face

HAVE YOU ever thought of how many different ways there are today of sending messages to people? If you have, you might have said to yourself, "Sending messages depends upon whether you are near people or are far away." And that is very true.

When you are with people "face to face," as we say, you can speak words that they can hear. If they understand your language (English or French or German, or whatever it may be) they can understand what you are saying. We call this way of sending messages "communicating by spoken language."

Or you can even give someone a message without speaking. You can shake your head instead of saying "No," or nod it in place of saying "Yes." If people know each other very well, a smile or a frown can often tell what they mean. "I don't know" may be said by shrugging the shoulders. "Is that really true?" may be expressed by raising the eyebrows or otherwise making your face into a "questioning" expression. We call this way of sending messages — moving the head, arms, hands, fingers, or the face — "communicating by gestures."

Scientists think that long before men had a spoken language they communicated by gestures. You can make up an interesting game by seeing how many different ways you can send messages to people by using gestures.

Spoken language and gestures are the chief ways that people now use to communicate, or send messages to one another, when they are near together.

Communicating When People Are Far Apart

When people are so far apart that they cannot see or even shout to one another, how do they send messages?

"That's easy," we can hear you say with a smile. "They can write a letter and send it by messenger or by the post office. They can telephone or send a telegram or a radiogram."

"How far can they send such messages?"

"Oh, around the world, if necessary. Across the continent by telephone, telegraph, or post office. Across oceans by submarine telegraph or telephone or radiogram. Even up into the air, by radio, to someone in an airplane or an airship."

It might be difficult for you to understand, but all these ways of communicating are very new. Some of them were unknown 40 years ago! Of course for many thousands of years people were trying to communicate with one another over long distances. Let us read a bit of the history of communication and see how they discovered how to do so.



Rodney Thomson

FIG. 174. Among other things the Indians taught the white man to send up smoke signals. By this means he could communicate with them and with other settlers if he needed their help

1. Sending Messages by Sight Signals

Puffs of Smoke and Flashes of Light

The Indians of North America used smoke signals to send messages. They built fires that sent up clouds of smoke into the air. By covering and uncovering the fires certain messages could be given. Each tribe had its own smoke language, or "code," of signals. A message of danger was given by sending up short puffs of smoke; long puffs meant that everything was safe. As time passed, clever codes were invented; certain kinds

of smoke clouds stood for certain ideas. By standing on high hills or climbing into trees, the Indians could read one another's messages a long way off. At night they signaled through the darkness by waving burning torches or by burning fires on the tops of high places. To do this, of course, they had to have a special code of signals which all the tribes knew.

When the white people came among the Indians, they learned what many of these signals meant. They discovered that the Indians were warning one another of the coming of the white strangers. They were passing the word along that some of these newcomers seemed to be enemies; that others seemed to be friends.

The Persians and Greeks of 2500 years ago had a clever way of giving signals on sunny days. They held up brightly polished shields which reflected the rays of the sun. A soldier standing on one hilltop could send flashes of sunlight to a point far away, thus sending a message by moving the shield in certain ways.

Of course such signals could not always be depended upon. If the weather was cloudy, the sun's rays could not be seen. If it was foggy or windy, the smoke and fire would not do what was expected of them. Another weakness of such signals was that the messages could be understood by enemies as well as by friends.

Wigwagging by Semaphores

Perhaps the most exact of these "long distance" conversations was by "wigwagging." Those who were going to give the signals stood on hills or high towers



Ewing Galloway

FIG. 175. This Boy Scout is sending a message by wigwagging

as far away from each other as the eye could see. In each hand they held a flag, which they moved in ways that both of them understood. Each position, or movement, meant a certain letter of the alphabet, and the words of the message were spelled out by the movements. Imagine how much time and how many movements it took to put a really long message together!

Later, instead of using the arms of people to do the wigwagging, poles were set up and "arms" of wood or metal were attached to them. These could be moved in certain ways. The pole and its arms are called a semaphore. No doubt you have seen semaphores in

the railroad yards, where they give signals to trains. Have you noticed how the arm of the semaphore is vertical when it is safe for the train to pass on? When there is a train ahead, it stands crosswise as if barring the way.

A set of signals like this was erected in England between the cities of Dover and London at the time the French and the English were at war. It was 1815, and the battle of Waterloo was being fought. Napoleon was the French general and Wellington was the English leader. Of course in those days there were no telephones or telegraphs. The only way that news could come from France was by messenger to the English Channel, then by ships as fast as their crews could carry it across the Channel to Dover. From there it was signaled by semaphore to London.

Of course the English people were very eager to get the news of how the battle was going. They watched for the signals anxiously. At last the message started to come over the semaphores. The first two words, "Wellington defeated," were being read when a heavy fog set in. Can you imagine the feelings of the English people at getting that news? Imagine their surprise, however, when a messenger arrived on horseback the next day with the full message, "Wellington defeated Napoleon today!"

As with smoke signals, the semaphore's success as a way of communicating depended on the weather. Even as late as the 1840's this system was used in both Europe and the United States.

2. Sending Messages by Sounds

Whistling

The history of communication is filled with interesting stories of how man learned to send messages far away by sounds. Perhaps one of the first ways was by whistling. No doubt someone discovered that a whistle can be heard farther than a cry or a shout. Even today the shepherds in the Canary Islands carry on long conversations by whistling across the hills for a distance of three or four miles. Through all the years they have built up a whistling code. Otherwise they could not understand one another.

There is an old story about a rich man who owned many of the farms on the Canary Islands. He was very curious to know what the shepherds on his farms were saying to one another, so secretly he took lessons in whistling. Within a short time he knew the meaning of every musical note. Then, one day, he set out to visit his farms. No sooner had he started than from hill to hill he heard the signals which the shepherds were giving to one another. Not only were they telling about his coming; they were making sure that a cow or a pig which they were to pay him as rent would be hidden away so that he would not see it!

Drums

In other parts of the world many other kinds of sound signals have been developed. Even today such signals are used among nature peoples. Figure 176 shows some drums in the Fiji Islands on which messages are



FIG. 176. These Fiji Islanders are still using the same drums which their ancestors used to call the tribe together for feasts or war

beaten. The sound of these drums can be heard for miles through the jungle. When the explorer Lange was in South America several years ago, his native guide sent this message ahead: "A white man is arriving with us. He seems to have a good heart and to be of a good character." The answer came in the same way, "You are welcome if you place your weapons in the bottom of the canoe."[1]

[1] For this and other factual material contained in this chapter indebtedness is acknowledged to the New York Telephone Company.

Guns and Bells as Sound Signals

The firing of cannon and the ringing of bells were also used as signals. When the Erie Canal was opened in the United States in 1825, there was a great celebration. The time when the first boat entered the canal from Lake Erie at Buffalo was to be announced in New York City by the firing of cannons. Men and cannons had been placed at regular places along the way. When the men at the second cannon heard the booming of the first one, they touched off the second cannon. The sound of the second was the signal for the men at the third cannon to fire theirs, and so on to the end. It took about an hour and a half to relay the message from Buffalo to New York City.

These ways of communicating, however, were neither very exact nor rapid. Signs and sounds were likely to be misunderstood. Better ways simply had to be found.

3. Written Messages Take the Place of Sight and Sound Signals

Early Runners

In answering our question at the beginning of the chapter about ways of sending messages, you might have said, "I would write a letter." That sounds very simple today, but it was no simple matter for man to invent a way of doing it! It took thousands and thousands of years for him to learn to put his ideas into writing. The story of writing is a very thrilling one,



FIG. 177. The Greeks trained runners to deliver messages

and you will read it in *Man at Work: His Arts and Crafts.* For now we can just say that as soon as any people had a system of writing they could send written messages.

But how do you suppose written messages got to the people for whom they were intended? You can guess that answer from your story of transportation. You know that for early peoples all the carrying of messages, as well as of goods and people, was done by men — runners.

The records of ancient peoples, such as the Egyptians, tell us that runners carried messages written on a kind of paper called "papyrus," or on flat bricks of

sun-baked clay, or on tablets of stone. These runners often traveled fast, but you can realize what a long time it took to carry these messages for more than a few miles.

We are told in a Bible story that Haman sent letters by runners to the people of Israel and Judea, ordering that the Jews be killed on a certain date. But the date was to be eleven months from the time when the runners started out, for it would take nearly a year to tell all the people about it.

Runners were also trained as messengers by the Greeks of 2500 years ago. History tells us of many unusual long-distance runs made by these Greek messengers (figure 177). One of the most famous was Pheidippides, who is reported to have run from Athens to Sparta, a distance of 140 miles, in two days and two nights!

A Chinese "Postal System" of Long Ago

We do not know exactly when a "postal system," or a way of sending messages over regular routes, was begun, but an early record shows that the Chinese had such a postal system in the 1200's A.D. Marco Polo, a traveler to China from Venice in Italy, wrote in 1275, describing it in this way:

> From the city of Kanbula there are many roads leading to the different provinces, and upon each of these, at the distance of 25 or 30 miles, there are stations. . . . At each station are 400 good horses ready so that all messengers going and coming upon the business of the Grand Khan [Ruler] may leave their tired horses, and be supplied with fresh ones.

In the space between the stations there are small villages at a distance of every three miles, which may have about 40 cottages. Here are the foot messengers, who are also employed in the service of His Majesty. They wear girdles around their waists, to which several small bells are attached, in order that their coming may be heard at a distance. As they run only three miles, the noise of the bells can be heard for some distance and a fresh messenger is ready to go on with the packet as soon as the first one arrives. It is carried from station to station so quickly that in the course of two days and two nights His Majesty receives messages from far away that could not be sent formerly in less than ten days.

This postal system of the Chinese at the time of Marco Polo was used mainly by the rulers for sending messages and commands. Later in England and other European countries the first regular messengers were those who carried orders from the king. This seems to have been true in all times and all over the world. Governments have always found it necessary to keep in touch with all parts of the country.

In later times, however, trade within countries and between countries grew. Then it was the merchants and manufacturers who became interested in more rapid ways of communicating. Unless the merchant went from house to house he had no way of reaching his customers except by sending a letter. If he wished to make his business larger, he had to have regular ways of keeping in touch with each customer. Therefore it was often the business men who began the postal systems.

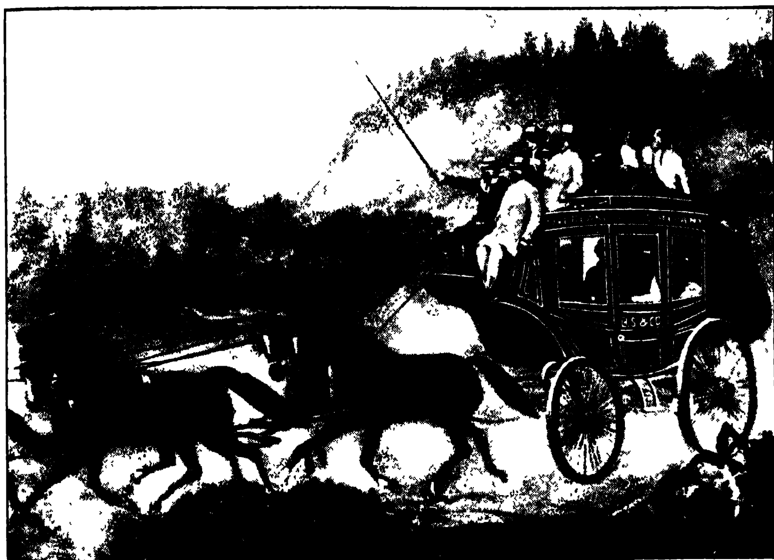
How Mail Was Sent in America during the 1700's

You remember that up to 1790 nearly all the American people lived on the Atlantic coastal plain. Ways of traveling, compared to ours, were slow and uncertain, chiefly because messages depended upon transportation. By the middle of the 1700's mail started out from New York City to Philadelphia, a distance of not quite 100 miles, three times a week. But once having started, no one could be sure when it would arrive. It had to travel by stagecoach over very rough roads.

Benjamin Franklin was one of the first leaders of our country to see how necessary it was to have rapid and safe ways of communicating. As early as 1753 he organized post offices and postal routes and became himself the first Postmaster-General of the American colonies. Roads were improved so slowly, however, that by 1790 there were only 75 post offices in our entire country. One can understand how uncertain the schedules were from the fact that no letters, no newspapers, books, or parcels, left any post office until enough of them had been received at the post office to pay for sending them. Furthermore, the charge, which ranged from about six cents to twenty-five cents for each, was decided not by weight, as it is today, but by the distance the letter was going.

The Postal System during the 1800's

As you know, the westward movement of our people began about 1790. Within 50 years they had ex-



United States Post Office Department

FIG. 178. By 1858 mail was carried across the plains in the Overland Mail Company's coaches

plored and begun to settle the entire land from coast to coast. As they scattered farther and farther over this vast territory, they began to think about the matter of communication. How could they continue to send messages to one another as the distances between became greater? Many Americans feared that as the continent became settled various parts of the country would split up into several different nations. We know, of course, that this did not happen, but the real reason for keeping them together was that transportation and communication improved rapidly.

The Pony Express Carries the Mail

After 1830 railroads began to appear in the settled communities of the East and even in the new towns beyond the Appalachians. Wherever they ran they carried the mail. But even as late as 1860 railroads had not been built west of Missouri. In the 1860's the "pony express" was started. It took up the mail where the railroad ended.

The last railroad stop from the East was St. Joseph, Missouri. Between this city and the Pacific coast, stations were set up at various places. From station to station the mail was carried by messengers on horseback. Uncle Nick Wilson, one of the first riders of the pony express, gives us a glimpse of the way the mail was carried at that time. Here is part of his story:

A great "pow-wow" was going on about the Pony Express coming through the country. The company had begun to build its roads and stations. These stations were about ten miles apart. They were placed as near to a spring, or other watering place, as possible. There were two kinds of them, the "home station" and the "way station." At the way stations, the riders changed horses; at the home stations, which were about fifty miles from each other, the riders changed; and there they ate their meals and slept. . . .

When we were hired to ride the express, we had to go before a justice of the peace and swear we would be at our post at all times, and not go farther than one hundred yards from the station except when carrying the mail. When we started out we were not to turn back, no matter what happened, until we had delivered the mail at the next station. We must be ready to start back at a half minute's notice, day or night, rain or shine, Indians or no Indians. . . .

Well, the time came that we had to start. On the afternoon of April 3, 1860, at a signal cannon shot, a pony rider left St. Joseph, Missouri; and at the same moment another left Sacramento, California — one speeding west, and the other east over plains and mountains and desert. Night and day the race was kept up by the different riders and their swift horses until the mail was carried through. Then they turned and dashed back over the same trail again. Each man would make about fifty miles a day, changing horses four or five times to do it.[1]

The Railroads Carry the Mails All over the Country

With the coming of the railroads the pony express gradually went out of use. Nine years after Nick Wilson had started on that Western run the first railroad across the continent was completed. Of course many communities that were away from the main lines still received their mail by postriders, but as the branch lines were built in all parts of the country the "iron horse" began to take the place of the live horse.

Let us compare, for a moment, the pony express of 1860 with the mail car of one of our cross-country express trains. In 1860, with the swiftest express riders and stagecoaches, it took two weeks to carry a letter from the Mississippi River to San Francisco. Mail can now be carried across the entire United States in these trains in about 80 hours! Thus you can see how communication has speeded up as the speed of transportation increased.

[1] From Wilson-Driggs: *The White Indian Boy.* Copyright 1919 by World Book Company, Yonkers-on-Hudson, New York.

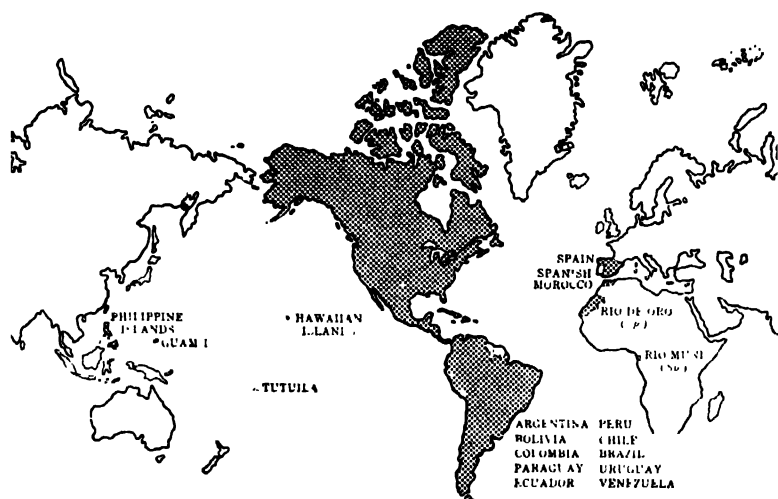


FIG. 179. This is the American postage map of the world. To all places in the shaded areas a three-cent stamp will carry an ounce letter. To all parts of the world left white on the map a five-cent stamp will deliver the letter

The Postal System of the United States Today

Today our postal system is one of the biggest businesses in the world. Each year the government of our country delivers hundreds of millions of letters to its people. For every second of the 24 hours of every day over 400 letters are dropped into letter boxes. Mail is delivered by wagon, by automobile, by railroad train, by airplane, by dog train, as well as by postmen on foot. Every known kind of transportation is used to do the work of over 51,000 post offices.

Day and night the postal workers are handling the

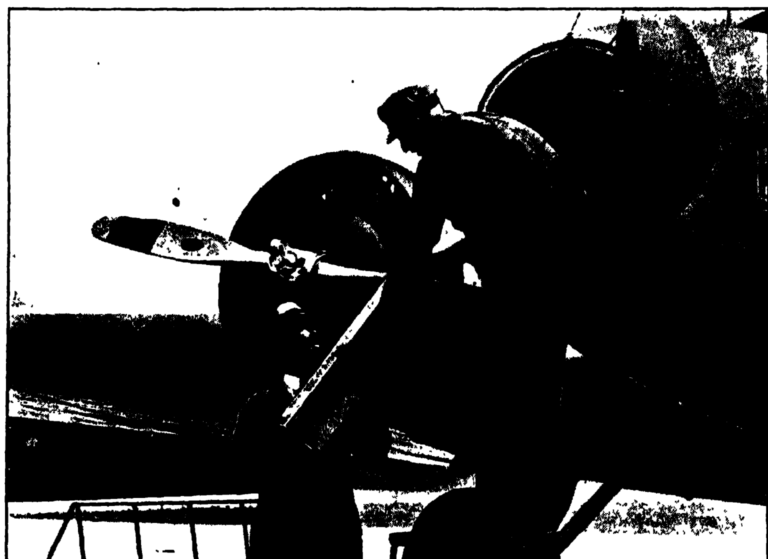
flood of letters and parcel-post packages. Thousands of these workers are needed to sort this mail and start it along the right way. The mails go into every village and every mountain district, no matter how far away or how much the cost. If automobiles or airplanes serve better, then they must be used. In the large cities the mail is shot through undergound tubes to make it travel as quickly as possible from one part of the city to another. The carrying of the mail is so important that the fast mail trains are given the "right of way" over all others. Some of the sorting of letters is done on the train as it speeds along.

Can you begin to realize what a vast business the postal service of our country is?

The Air-Mail Service

On May 15, 1915, the United States air-mail service was started with the opening of the first route between Washington and New York City. This route was thought of as an experiment, but it was so successful that during the next year air-mail service was extended from New York to Cleveland and then on to Chicago. Less than a year later the service reached all the way across the continent from Boston to San Francisco. Branch routes were started connecting Minneapolis and St. Louis to Chicago. Year by year the mileage of the air-mail system is increasing.

At first the mail airplanes flew only in the daytime, but in 1921 night service was begun as well. Flying both day and night, a plane can now transport mail



Ewing Galloway

FIG. 180. The latest way in "air express" from the Atlantic to the Pacific

from the western coast to the eastern coast in fourteen hours. It is important to remember that a single plane can carry as many letters as a railroad mail car.

These mail planes are almost as regular in keeping on schedule as are the railroads. The mail must go in rain or shine, heat or cold. Like the railroads, the air service has regular stations, the main ones being about 400 miles from one another. Between these main airports, which are usually located in the large cities, smaller stations have been built at spots about 100 miles apart.

An interesting change has taken place recently in

the ownership of the air lines. Until 1927 they were owned and run by the United States Post Office Department. Since that date they have been turned over to private companies which have made arrangements with the government to do this.

In this chapter we have seen how men learned to send messages to one another. At first they tried to express with grunts and gestures what they were thinking. Through millions of years they developed a written as well as a spoken language. All during that time they were trying to communicate over longer and longer distances. At first messages could go only so far as eyes could see and ears could hear; but with the invention of new kinds of power and new ways of transportation, they could go as far and as fast as vehicles could carry them. Thus with trains and airplanes and automobiles, communication became swifter and more certain.

But, except when communication was face to face, it was always dependent on transportation. Letters had to be carried; they had to be delivered by someone or something.

In the 1800's, however, new ways of communicating were discovered. They did not depend upon transportation but upon a new kind of power. In the next chapter we shall see what important things this new kind of power did for communication.

Books You Would Like To Read

BEARD, D. C. American Boys' Book of Signs, Signals, and Symbols. J. B. Lippincott Company, Philadelphia. A simple explanation of all kinds of signs, such as secret writing, signal codes, railway signals, and hobo and Indian signs.

CORBIN, T. W. The Romance of Light Houses and Life Boats. Seeley Service and Company, London. The story of lifesaving, including a description of lightships, rockets, and signaling under the sea.

GEORGE, LLOYD, and GILMAN, JAMES. Modern Mercuries. Robert M. McBride & Company, New York. The story of communication.

LAMBERT, CLARA. Talking Wires. The Macmillan Company, New York. A fascinating photographic picture book taking you step by step with a telephone call as it goes from San Francisco to New York.

MCSPADDEN, J. W. How They Sent the News. Dodd, Mead & Company, Inc., New York. How messages have been sent through space by sight, sound, or electric signal, beginning back about 25,000 years ago with messages left on walls of caverns in southern France, drums of Africa beating out code messages, and Indian "smoke words in the sky."

WALKER, JOSEPH (Pseud.). How They Carried the Mail: From the Post Runners of King Sargon to the Airmail of Today. Dodd, Mead & Company, Inc., New York. A history of mail systems centering around outstanding carriers.

WEBSTER, H. H. The World's Messengers. Houghton Mifflin Company, Boston. An interesting account of devices evolved by man for purposes of communication.

CHAPTER XXIII

Talking Wires

IMAGINE yourself waking tomorrow morning to find that, except for human or animal muscles, every way of carrying people or goods and of sending messages has stopped. You walk from your house to the corner where the streetcar usually takes you to school. The car fails to appear. After standing for a long time on the corner you decide to walk. As you go, you can see taxicabs stalled here and there. Their drivers are still sitting in some of them, but not any of the cars will move. Trucks and automobiles stand idle along the way.

In the distance is a streetcar. You hurry up to it, but find it empty. The motorman and the conductor do not know when it will go or if it will go. How deathly silent the streets are! Not even a horse-drawn wagon is in sight! Yes, there is one just coming around the block — but only one, for it is a long time since horse-drawn vehicles were used in large numbers.

What has happened to bring about this change? You decide to buy a newspaper to find out, but there is no morning paper on the newsstand. This is all so strange that you return to your house and find a message which arrived just before communication stopped. It tells you that your grandmother, who lives 100 miles

away, is ill. You seize the telephone; there is no sound of life in it. Impatiently you try to get the attention of the operator, but the telephone is "dead." You run to the telegraph office in the next block and ask for a blank to send a message. The clerk tells you, "Sorry, but the wires are not working."

"I'll try the wireless!"

"Out of order."

"The trains!"

"Not running."

"It's only 100 miles; I'll go by automobile."

"There is none to be had; every motor is stalled."

"Well, even though it is expensive, I'll rent an airplane."

"Not one in operation!"

Do you know why all these things which help us to carry on our work and play might be "dead," unable to move? It would all be because of one thing — *electricity*. You have already read the story of how electricity changed ways of carrying goods and people. Let us see how inventions using electricity changed ways of sending messages.

Samuel F. B. Morse Invents the First Electrical Telegraph (1844)

In the *Building of America* you read how Samuel F. B. Morse was introduced to the idea of the telegraph while returning from Europe in 1832. A fellow passenger who had been studying electricity had

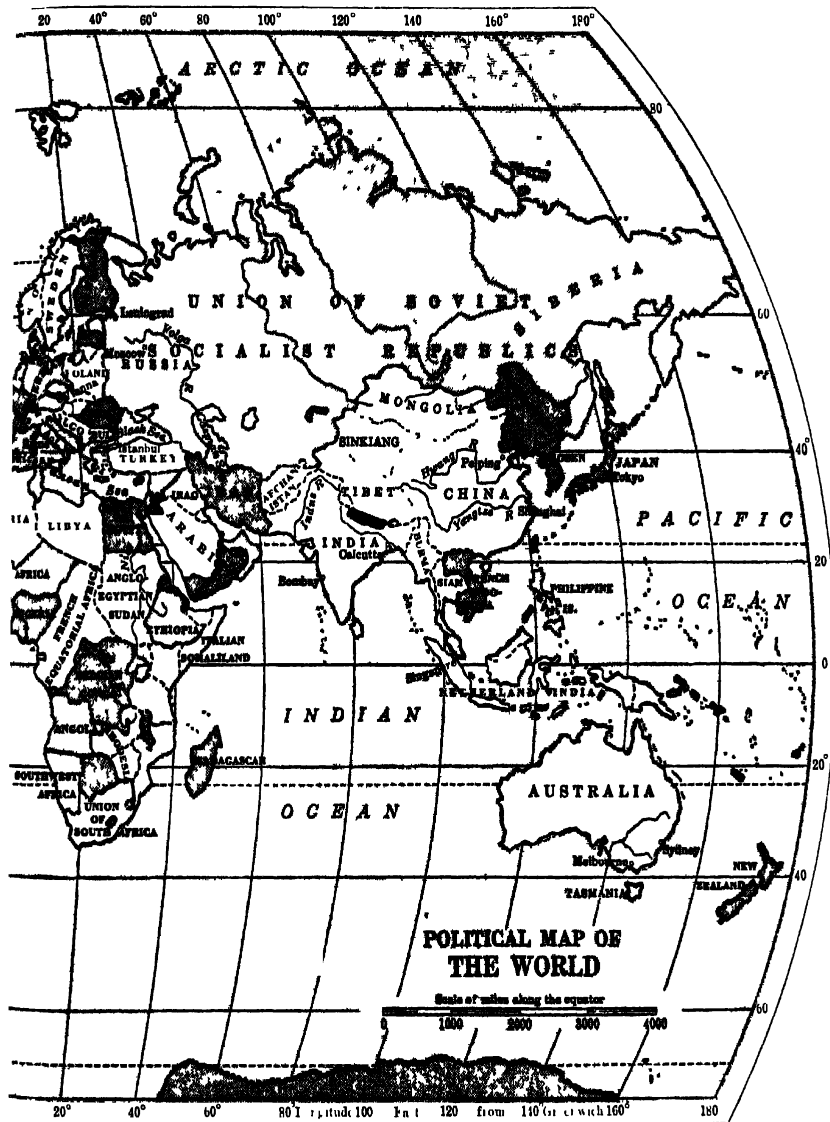
brought with him an electromagnet which Morse examined with great interest. Immediately Morse was struck with a new idea — that electric signals could be sent long distances over wires by means of this kind of instrument. Upon his return to America he gave almost all his time trying to invent such an instrument.

The difficulties which he met were many. He was poor; he had little mechanical skill or scientific knowledge. But he was an artist, and he was able to secure a position as professor of art in the University of the City of New York. This gave him a place in which to carry on his work. Here he was also helped by one of the professors of science.

An interesting story is told by General Strother, who was at one time one of his pupils. This shows very well indeed how Morse was forced to struggle against poverty and even starvation. Strother says:

"I became Morse's pupil, and went to New York. I found him in a room in University Place. He had three other pupils, and I soon learned that our professor was receiving very little help. I paid fifty dollars for one quarter's teaching. Morse was a faithful teacher, and took as much interest in our progress — more, indeed — than we did ourselves. But he was very poor. I remember that when my second quarter's pay was due, the money I was to receive from home had not come. One day the professor came in and said politely, 'Well, Strother, my boy, how are we off for money?'


ARCTIC OCEAN
GREENLAND
Arctic Circle
CANADA
LABRADOR
NEWFOUNDLAND
UNITED STATES
Chicago
New York
Los Angeles
ATLANTIC
Tropic of Cancer
Gulf of Mexico
MEXICO
WEST INDIES
Caribbean Sea
CENTRAL AMERICA
PACIFIC
OCEAN
Equator
ECUADOR
Amazon R
PERU
BRAZIL
Rio de Janeiro
Tropic of Capricorn
OCEAN
ARGENTINA
Buenos Aires
Antarctic Circle
180
160°
140°
120°
100
80
60
40
20
80°
60°
40°
20°
0°
Longitude West from Greenwich


ARCTIC OCEAN
UNION OF SOVIET SOCIALIST REPUBLICS
SIBERIA
Leningrad
Moscow
RUSSIA
Volga
SWEDEN
POLAND
Black Sea
Istanbul
TURKEY
LIBYA
IRAQ
ARABIA
MONGOLIA
SINKIANG
AFGHANISTAN
TIBET
CHINA
Peiping
JAPAN
Tokyo
Shanghai
Yangtze R
Indus R
INDIA
Calcutta
Bombay
BURMA
SIAM
PHILIPPINE IS.
PACIFIC OCEAN
ANGLO-EGYPTIAN SUDAN
ETHIOPIA
ITALIAN SOMALILAND
FRENCH EQUATORIAL AFRICA
ANGOLA
MADAGASCAR
SOUTHWEST AFRICA
UNION OF SOUTH AFRICA
INDIAN OCEAN
Singapore
NETHERLAND INDIA
AUSTRALIA
Sydney
Melbourne
TASMANIA
NEW ZEALAND
POLITICAL MAP OF THE WORLD
Scale of miles along the equator
0 1000 2000 3000 4000
20° 40° 60° 80 100° 120° 140 160° 180°
80 60 40° 20 0 20° 40 60

"'Why, Professor,' I answered. 'I am sorry to say I have been disappointed; but I expect the money to arrive next week.'

"'Next week!' he replied sadly. 'I shall be dead by that time.'

"'Dead, sir?'

"I was distressed and astonished. I said hurriedly, 'Would ten dollars be of any service?'

"'Ten dollars would save my life; that is all it would do.'

"I paid the money, all that I had, and we dined together. It was a modest meal but good, and after we had finished, Morse said:

"'This is my first meal for twenty-four hours. Strother, don't be an artist. It means beggary. Your life depends upon people who know nothing of your art and care nothing for you. A house dog lives better.'"

We cannot tell the whole story of the telegraph here, and it is difficult to understand unless you have studied a good deal about electricity. You know that scientists had discovered that electricity could be sent almost at once through wires over a distance of several miles. Strangely enough, no one before Morse had thought that by *starting* and *stopping* the current a message could be sent.

Once having hit upon the idea of sending messages in this way, Morse had three hard problems to solve. The first was to make suitable instruments, the second was to make enough current to send the electricity over



Rodney Thomson

FIG. 181. The artist imagines Samuel F. B. Morse working out the model for his first telegraph

long distances, and the third was to invent a "code" by which the messages could be sent.

Morse had as a student in one of his classes a young man named Alfred Vail. Vail had unusual mechanical ability and a deep interest in Morse's invention. He persuaded his father to give Morse enough money to make instruments, and he himself spent several years working on them. Morse came to depend a great deal upon the younger Vail's cleverness and upon the older Vail's support with money.

Morse Tries To Get Help from the United States Government

Much more money was needed to build a trial telegraph than any one person was willing to provide. There were poles to be bought and erected, wires to be strung, machines to be made. All these things would cost thousands of dollars. Morse tried to get our government to give him the money. For several years he argued and pleaded with Congress to experiment with his new invention — an invention which might well change the lives of people in a thousand ways. For years Congress did little or nothing. Finally, on February 23, 1843, they did consider the matter and voted to spend $30,000 on Morse's invention.

Morse finally invented a code, an alphabet for sending messages over wires. This consisted of a series of long and short marks on a moving piece of paper. These were called "dots" and "dashes" which were made by stopping and starting the current in the instrument. The tap of a key at one end of a wire through which the electric current was passing caused a small bar at the other end to make a mark. The alphabet was made of long and short marks, which stood for letters. The telegraph operator could tap out these marks, which were put together into words. Another operator at the other end of the wire could understand and write down the message, no matter how far away it was. You have no doubt heard a telegraph machine when you were waiting to send a message at the



Fig. 182. History of Communication

telegraph station or while you were buying a ticket at the railroad station.

On May 24, 1844, the lines were ready for use, and Morse sent this message, "What hath God wrought," to Alfred Vail, who was in Baltimore, 40 miles away. Immediately the same message came back: "What hath God wrought."

Since Morse's time many improvements have been made in the telegraph. With the instrument which he invented only one message could be sent at a time over a single wire. A few years later it became possible to send two messages at the same time. Many years ago Thomas A. Edison invented a system by which four messages can be sent over the same wire at the same time. More recently the scientists of a telegraph company invented a way to send eight messages.

At first people were slow to make use of the new way of sending messages; but soon the big companies, such as the railroads, began to use it. In less than ten years most of the railroads were giving orders to their employees and managing their trains by telegraph. What a difference it made! Trains could now be controlled from central offices far away. They could be run much more regularly and safely.

The telegraph soon began to be used as a message carrier. No longer did people have to write all their messages in letters and send them by postal service. Brief and important matters could be sent almost immediately by telegraph.

By 1861 the first telegraph line, stretching from

coast to coast, was completed. At that time, too, more than 50,000 miles of telegraph wire connected the bigger cities of the country with one another. A message could be sent from Washington to New York or from Paris to Berlin. But the continents were still ocean voyages apart. The next step was to make it possible to send a message by telegraph across the ocean.

Cyrus W. Field Lays the First Submarine Telegraph (1858)

Morse now began to work on the idea of sending messages under the water as well as through the air. He discovered that if the wires were wrapped so as to keep out all dampness they could be strung under water. Even before the telegraph line between Washington and Baltimore had been set up, he had run a cable, a kind of metal tube, carrying telegraph wires under the waters of New York Bay, but it was broken by the anchor of a ship and was never used.

In 1850 a cable was laid across the English Channel joining England to the mainland of Europe. Shortly afterward another cable was laid to connect England with Ireland. At the same time people were suggesting a line from New York to Newfoundland and from Newfoundland to Ireland. (If you look at a map showing the continents, you will see that Newfoundland is much nearer to Europe than the United States is.) Others were thinking of a plan to connect Europe and America by building a telegraph line from Europe across Russia, Siberia, then under Bering Strait, and on across North America to the Atlantic coast.

"Why not lay a cable straight across the Atlantic Ocean?" asked Cyrus W. Field.

For many years Field had been a successful New York business man. At the age of thirty-four he had a fortune of $100,000. He decided to spend his time trying to lay a cable beneath the Atlantic. There were many difficulties and many problems. Field used his own money until it was entirely spent. Then he turned to others for help. Finally both the British and the United States government agreed to give some money to the company which Field had started.

Four times in 1857 and 1858 this company tried to lay a cable between Europe and North America. At last, on August 5, 1858, Field was able to send the following telegram:

TRINITY BAY, NEWFOUNDLAND
AUGUST 5, 1858

MRS. CYRUS W. FIELD
84 W. 21 STREET
NEW YORK

ARRIVED HERE YESTERDAY. ALL WELL.

THE ATLANTIC TELEGRAPH CABLE SUCCESSFULLY LAID. PLEASE TELEGRAPH ME HERE IMMEDIATELY.

CYRUS W. FIELD

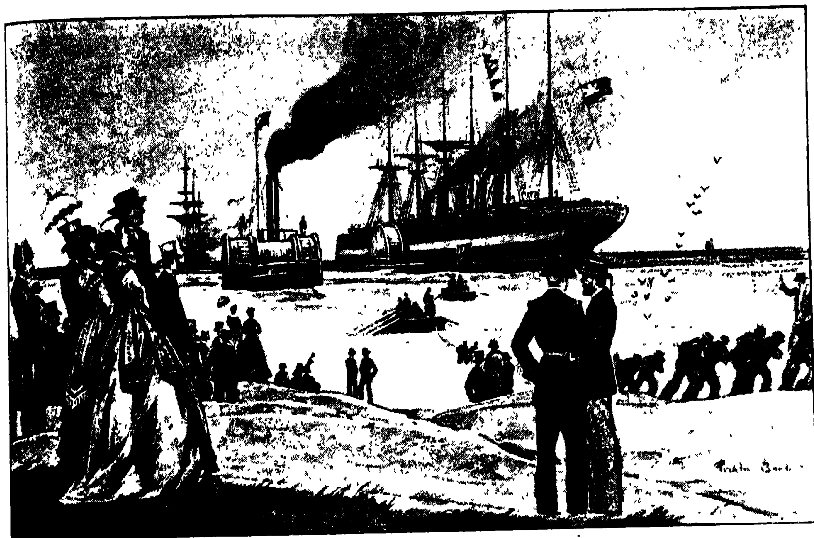
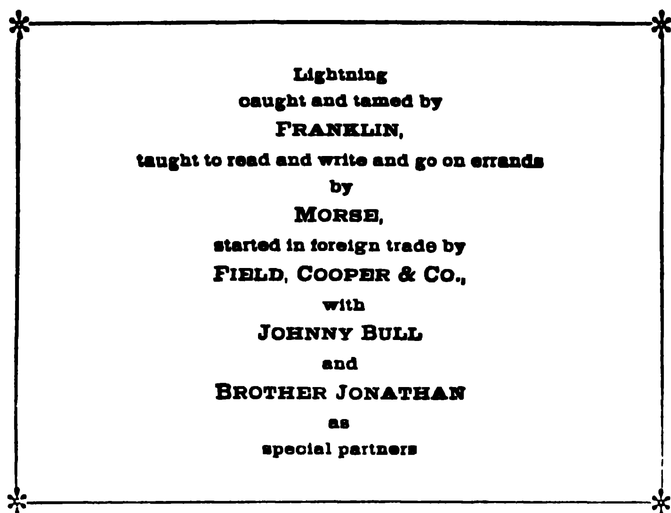


FIG. 183. The end of the transatlantic cable is brought ashore



FIG. 184. An exciting moment. The first message comes through the cable

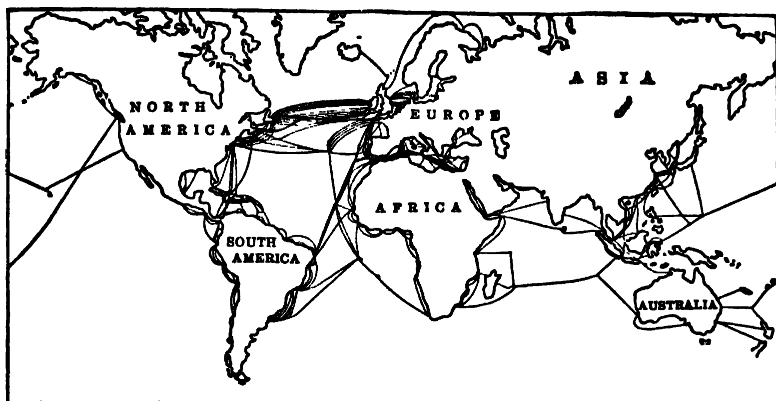


Celebrations were held on both sides of the Atlantic The members of the Atlantic Telegraph Company were welcomed as heroes, and dinners and receptions were given them. Posters like the one above were made.

But the troubles were not yet over. Time after time the cables broke; other accidents happened; each time the company had to start all over again. But Field was determined to connect Europe and America by cable. He crossed the ocean 37 times, forming one company after another and spending huge sums of money. He succeeded at last in 1866, and the submarine telegraph became possible.

The Cable Becomes Important to the Nations of the World

As the poster suggests, "Johnny Bull," who stands for England, and "Brother Jonathan," who stands for



Journal of the American Institute of Electrical Engineering

Fig. 185. This map shows where the principal submarine telegraph cables of the world are now laid

the United States, were joined by the undersea telegraph. From the date of Field's success each of the chief European countries began to make use of the submarine telegraph. Great Britain, the United States, France, and Germany took the lead in this work.

The first cables between Europe and North America were owned by British companies. It was not long before American companies were formed which laid cables to Europe, to Mexico, to Central America and South America. French and German companies joined their countries to North America. Submarine cables were laid from France and other European countries directly to South America. Other lines were built through the Mediterranean. Still others joined western Europe and the southern end of Africa, as well as Africa and various parts of Asia.

Can you guess why some of the countries of the world were so eager to have undersea telegraph lines? There are many reasons, but three are perhaps most important: the gain to trade, to government, and to the gathering of news.

Swift communication helps trade. The business men of each of the leading countries buy from and sell to those of nearly all other countries. By means of the telegraph, companies located 10,000 miles away from each other can give and take orders within a day. Without the telegraph, weeks or months would be required.

Each government also uses the submarine telegraph. By means of it the officials of those governments can send messages instantly to their officers located in distant countries. In this way they can learn each day of important events. The submarine telegraph also makes it possible for all of us to hear news from all over the world. Newspapers in thousands of communities in every industrial country print the story of events that have taken place on the other side of the earth within a few hours of their happening.

Do you see now how communication has become faster and faster through the years of man's life on earth? Do you know what it means when someone says that the earth is becoming smaller and smaller?

The telegraph was not to be the only electrical means of communication, however. Still other ways were to come. Let us see what they were.